Local knowledge and livelihoods: tools for soils research and dissemination in Ghana

"Bridging Knowledge Gaps between Soils Research and Dissemination in Ghana" (DFID PROJECT R7516)

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LOCAL KNOWLEDGE AND LIVELIHOODS: TOOLS FOR SOILS RESEARCH AND DISSEMINATION IN GHANA

There are three tools contained in this pack. They are:

1. The Agroecological Knowledge Toolkit
2. Livelihood and land use diagrams
3. Technology Choice Tool

Livelihood and land use diagrams and the Technology Choice Tool are paper based tools, whereas the Agroecological Knowledge Toolkit requires the use of a computer.

FARMERS' KNOWLEDGE OF NATURAL RESOURCE MANAGEMENT: USING THE AGROECOLOGICAL KNOWLEDGE TOOLKIT (AKT):

This tool is for exploring knowledge of soil fertility management held by farmers, researchers and extensionists in the forest and forest-savanna transition zones of Ghana. Farmers' local knowledge from five different areas of the Brong Ahafo, Ashanti and Western regions has been recorded, in addition to the knowledge of researchers and extensionists working with cover crops in the Brong Ahafo region. The tool includes the Agroecological Knowledge Toolkit software, six knowledge bases and the instructions for using them.

To use this tool you will need the instructions that follow and you will have to install the software and knowledge bases from the CD Rom that is included in this pack.

LIVELIHOOD AND LAND USE DIAGRAMS

This is a tool for synthesising information about rural livelihoods. It is intended to be used as part of a Participatory Rural Appraisal exercise to help researchers maximise use of existing information, to bring greater definition to PRA exercises and to guide researchers in thinking about different social groups. The tool focuses on land use as this is considered to be highly significant to the majority of rural livelihoods, although users may adapt the tool as appropriate to include other aspects of livelihoods.

This is a paper based tool. To use this tool you will need the instructions that follow using some qualitative and/or quantitative data about land use, cropping activities and other sources of income gathered from a PRA exercise or another data source.

TECHNOLOGY CHOICE TOOL

This tool brings together information about livelihoods and technologies to facilitate the choice of appropriate technologies based on farmers' circumstances. It can be used to determine which groups of farmers a particular technology is suitable for and hence to prioritise research work in consideration of its potential impact, or to produce a technology specification for a target group.

This is a paper based tool. To use this tool you will need the instructions that follow and some qualitative and/or quantitative data about livelihoods and corresponding information about the requirements of a particular soil fertility technology.

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FARMERS' KNOWLEDGE OF NATURAL RESOURCE MANAGEMENT: USING THE AGROECOLOGICAL KNOWLEDGE TOOLKIT (AKT)

USING FARMERS' KNOWLEDGE

Nowadays, nearly everybody agrees that local knowledge and practices should be recognized in development initiatives aimed at technology development by and for rural farming communities. Interest amongst research, education and development institutions to investigate and document local knowledge has grown significantly over the last few years.

The University of Wales, Bangor is a leading institution in the development of a knowledge-based systems (KBS) methodology to acquire and use local knowledge in research and development. The university spearheaded the development of this novel approach to acquire, store and use local ecological knowledge about agroecosystems in collaboration with various national and international research institutions in Asia, Africa and Latin America. It promotes systematic collection and collation of ecological knowledge from farmers and development professionals. The Agroecological Knowledge Toolkit (AKT5) is a tailor-made computer software that enables representation of statements of knowledge in a computer readable form which allows exploration of local ecological knowledge using computer based search and reasoning facilities.

Work so far has revealed that farmers in general have sophisticated knowledge of ecological processes occurring in the farming system and that local knowledge is largely complementary to scientific knowledge, but is not taken into account when planning research. While knowledge differs to some extent between communities, a common framework and terminology occur across large distances.

THE AGROECOLOGICAL KNOWLEDGE TOOLKIT (AKT5)

What is the purpose of this AKT guide?

The instructions that follow will guide you through six existing *knowledge bases* created in the south of Ghana. By following these instructions you will be introduced gradually to the *AKT* software, at the same time as learning about farmers' knowledge of soil fertility management in Ghana.

This publication is not intended to guide users through the creation of their own knowledge bases. The methodology for creating knowledge bases from knowledge elicited from stratified sectors of the population using iterative semi-structured interviews can be found in the user manual - Dixon *et al.* (2001). The principles of knowledge base creation have also been explained Sinclair and Walker (1998) and Walker and Sinclair (1998)[1] or you may visit the AKT website at: http://www.bangor.ac.uk/afforum

What is AKT?

AKT is a methodology and software that enables the user to create a *knowledge base* about a chosen topic e.g. soil fertility management or vegetable pests, by collating knowledge from a variety of sources (generally farmers, scientists, extension workers and scientific literature). So far, AKT has been used primarily as an analytical research tool. However knowledge stored in this way can also be consulted by natural resource scientists and development workers. This publication takes a novel approach by guiding first time users of AKT through some existing knowledge bases created in Ghana.

What is knowledge?

To define *knowledge* is to enter a philosophical minefield, nevertheless an explicit definition is required in this context. For the purposes of AKT, *knowledge* is the outcome of the interpretation of data, independent of the interpreter. (Data is a recorded set of observations, either qualitative or quantitative). Thus knowledge is distinct from understanding, which is a result of the interpretation of knowledge or data and is specific to the interpreter.

What is a knowledge base (KB)?

A *knowledge base* is a store of knowledge. It consists, fundamentally, of a collection of *statements*. Each *statement* is tagged (referenced) with the source of the knowledge (which is generally either a person or a document).
Knowledge that is stored in this way is organised according to a number of principles:

- *Topics* arrange knowledge around specific subject areas e.g. 'weed management', 'soil fertility indicators'. *Topic hierarchies* gather similar topics under broader areas e.g. 'weed management' and 'grass weeds' both fall under the more general topic of 'weeds'.
- *Object hierarchies* organise knowledge about specific *objects* (material or conceptual things) under more generic terms e.g. *Triplochiton scleroxylon, Milicia excelsa* and *Ceiba pentandra* are all types of tree and would therefore fall under the more general object 'trees'.

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1 **Dixon H., Doores F., Joshi L., and Sinclair F., 2001** *Agroforestry Knowledge Toolkit for Windows: methodological guidelines, computer software and manual for WinAKT.* School of Agricultural and Forest Sciences, University of Wales, Bangor.
Sinclair F., and Walker D., 1998 Acquiring Qualitative Knowledge about Complex Agroecosystems. Part 1: Representation as Natural Language. *Agricultural Systems* 56, 3, pp.341-363
Walker D., and Sinclair F., 1998 Acquiring Qualitative Knowledge about Complex Agroecosystems. Part 2: Formal Representation. *Agricultural Systems* 56, 3, pp.365-386

THE GHANA KNOWLEDGE BASES

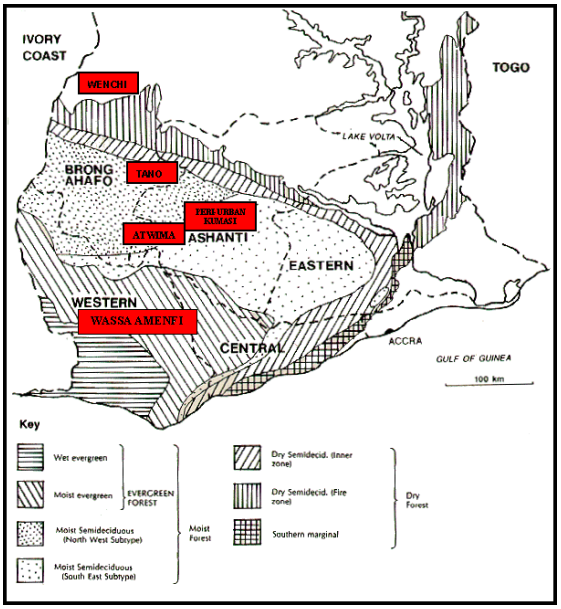
Six knowledge bases have so far been created in Ghana as part of the two DFID funded research projects – 'Bridging knowledge gaps between soils research and dissemination' and 'Shortened bush fallow rotations for sustainable livelihoods in Ghana'. A team of researchers from the Forestry Research Institute of Ghana, the Ministry of Food and Agriculture and the University of Wales, Bangor undertook the work during 2000 – 2001 in the forest and transition zones.

THE LOCAL KNOWLEDGE BASES

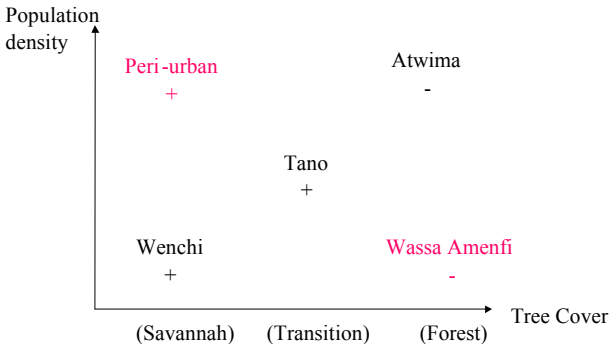
Five knowledge bases were created to record farmers existing local knowledge of soil fertility management in five different locations spanning areas of contrasting population density, forest cover and market access. They are:

1. Atwima knowledge base: farmers' knowledge from two villages in the Atwima district
2. Oda knowledge base: farmers' knowledge from four locations in the Asankrangwa area in the Wassa Amenfi district
3. Peri-urban Kumasi knowledge base: farmers' knowledge from four peri-urban villages around Kumasi
4. Subriso knowledge base: farmers' knowledge from Subriso No. 3 in Tano district
5. Yabraso knowledge base: farmers' knowledge from Yabraso in Wenchi district

Location of the five field sites within the forest and transition zones of Ghana



Characteristics of the five study sites



Key

Black	sites covered by the Shortened Bush Fallow project and the Knowledge Gap project
Red	sites covered by the Knowledge Gap project
+	good market access for the sale of food crops
-	poor market access for the sale of food crops

Further background information on livelihoods and farming at these sites can be found in Frost (2000); Moss (2000a); (2000b) and Obiri-Darko *et al.* (2000)[2].

Topics covered by the knowledge bases include:

1. ***Soil fertility***: the properties of good soil
   a. soil fertility
   b. soil moisture
   c. soil texture
2. ***Soil types***: the properties of different types of soil
   a. black soil
   b. red soil
   c. sandy soil
3. ***Soil fertility management***
   a. fallowing
   b. inorganic fertiliser

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2 **Frost, W. 2000**. *Farmers' knowledge of soil fertility and weed management in Atwima district, Ghana: The implications for participatory technology development.* Unpublished MSc. Thesis. University of Wales, Bangor. 91 pp.

Moss, C., 2000a. *Livelihoods and local knowledge of soil fertility management in peri-urban Kumasi, Ghana.* School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 24pp.

Moss, C., 2000b. *Livelihoods and local knowledge of soil fertility management at Oda-Kotoamso, Wassa-Amenfi District, Western Region, Ghana.* School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 38pp.

Obiri-Darko, B., Ayisi-Jatango, J., Anglaaere, L., Cobbina, J., Moss, C., McDonald, M., Sinclair, F., and Young, Einir., 2000. *Livelihood systems and farmers ecological knowledge in Ghana: a report on three districts.* Shortened Bush-fallow Rotations for Sustainable Livelihoods in Ghana (DFID Project R7446). School of Agricultural and Forest Sciences University of Wales, Bangor, U.K.

c. poultry manure
d. preparation of land after the fallow

4. ***Trees: their role in soil fertility management***
    a. trees and soil fertility
    b. trees and soil moisture
5. ***Weeds*** (see particularly the atwima.kb):
    a. weed management
    b. weeds as indicators of soil fertility

Different knowledge bases focus on different aspects of farmers' knowledge depending on the farming activities at each location and the knowledge of the informants. For example, the peri-urban Kumasi knowledge base is the only one to hold knowledge on the use of poultry manure, and no local knowledge base contains information on leguminous cover crops as informants had no knowledge of this technology.

THE COVER CROP KNOWLEDGE BASE

The cover crops knowledge base was created through compilation of information on cover crops from literature available in Ghana and from interviews with cover crop researchers and extensionists in Ghana. The majority of information available concerned mucuna as it has been better researched than other cover crops and therefore the majority of the statements in the knowledge base are about mucuna. Topics include:

- establishment of cover crops
- biomass production
- crop interactions with cover crops
- management of cover crops
- weed suppression
- varietal information

HOW TO CONSULT KNOWLEDGE BASES

Local knowledge can help researchers and development workers to explain the rationale behind farmers' actions and can contribute to developing appropriate solutions to development problems. Knowledge bases can be consulted in 4 main ways:

- by viewing sets of statements that fall under specific topics
- by performing a search for particular *terms* (words)
- by using customised *tools* (small computer programs supplied with AKT that interrogate and reason with the knowledge base)
- by representing statements on a *diagram* and using these to investigate causal processes.

A number of instruction sheets are included in this package which are aimed at enabling the user to consult the knowledge bases provided. It is suggested that the user starts with **A quick sightseeing tour around AKT** to familiarise themselves with the different functions of the software. Once this is completed the user can then move on to consulting the knowledge bases on particular topics of interest using any of the 5 examples provided:

- **Soil fertility: farmers' concepts**
- **What do peri-urban farmers know about inorganic fertiliser?**
- **Fallowing and soil fertility**
- **Trees and soil fertility**
- **Cover crops: local and expert knowledge**

These illustrate the type of knowledge contained in the knowledge bases and the ways to access it. After completing the **Quick sightseeing tour around AKT** the user will be able to consult knowledge bases using topics, searches and diagram exploration. These skills are reinforced and developed in the other examples and the use of AKT tools is introduced in **Trees and soil fertility**. Once the user has completed these sheets, or even before, they should be able to explore the knowledge bases independently of the instructions provided. Some information on performing basic functions within AKT is included below. A separate page, **Diagram instructions** shows how diagram functions are used. Definitions of key terms and concepts used in the instructions and in the software are included in the **Glossary**. However, the user should note that not all functions of the software are explained in this publication because the same software is used for both creating and accessing knowledge bases. The user manual (Dixon et al., 2001[3]) provides a comprehensive guide to the software and the creation of knowledge bases.

[3] **Dixon H., Doores F., Joshi L., and Sinclair F., 2001** *Agroforestry Knowledge Toolkit for Windows: methodological guidelines, computer software and manual for WinAKT.* School of Agricultural and Forest Sciences, University of Wales, Bangor.

OPENING, CLOSING, SELECTING, SAVING AND PRINTING KNOWLEDGE BASES

Opening AKT

Before opening a knowledge base, you must have the AKT program open. To do this double click on the AKT icon, and when prompted, click on **OK**.

Opening a knowledge base

To open a knowledge base go to **KB** → **Open KB…**, then select the knowledge base you want to open and click on **Open**.

Dialogue boxes

Users will notice that with AKT it is possible to have a large number of dialogue boxes open at the same time and these appear on the taskbar at the bottom of the screen. If new users find this confusing they should remember to close dialogue boxes once they are finished with.

Working with multiple knowledge bases

You can have more than one knowledge base open at the same time, but you can only work interactively with one knowledge base at the same time (unless you are using tools). The name of the current knowledge base is displayed at the top of the screen. To view which other knowledge bases are open go to **KB** → **Select KB…**. To switch between open knowledge bases you must then select the knowledge base you want and click on **OK**.

Printing parts of a knowledge base

It is possible to print sets of statements and diagrams from AKT.

- ***Printing statements***: There are 2 options for printing statements. You may print them out directly from the knowledge base, or you may save them as a text file and open them in another application such as Word, to view and print them. When you have the set of statements in front of you that you wish to print or save, click on **Print Statements**. You will then be asked if you want to save them as a text file. If you do, click on **Yes**, if you wish to print the statements directly from AKT click on **No**.
- ***Printing hierarchy diagrams*** You cannot print topic or object hierarchy diagrams directly from AKT. Instead you copy them to the click board and then paste them into another application such as Powerpoint, to view and print them. In order to do this, bring the diagram up on the screen (**View Tree**), then click on **Copy to Clipboard**. When you have done this, open the application that you wish to view them in, and click on the Paste command.
- ***Printing statement diagrams*** Statement diagrams (i.e. diagrams that represent a set of statements from the knowledge base) can be printed either directly from AKT or copied to another application. To print a diagram directly from AKT go to your chosen diagram and click on **Print Window**. To copy statement diagrams to another application, follow the same procedure as for printing hierarchy diagrams.

Saving a knowledge base

If you have made some alterations to the knowledge base which you want to save, e.g. by creating a diagram, you can save the altered knowledge base. Go to **KB** → **Save Kb As…** , specify a new name for the changed knowledge base and click on **Save**.

Closing a knowledge base

To close the current knowledge base go to **KB** → **Close KB…**

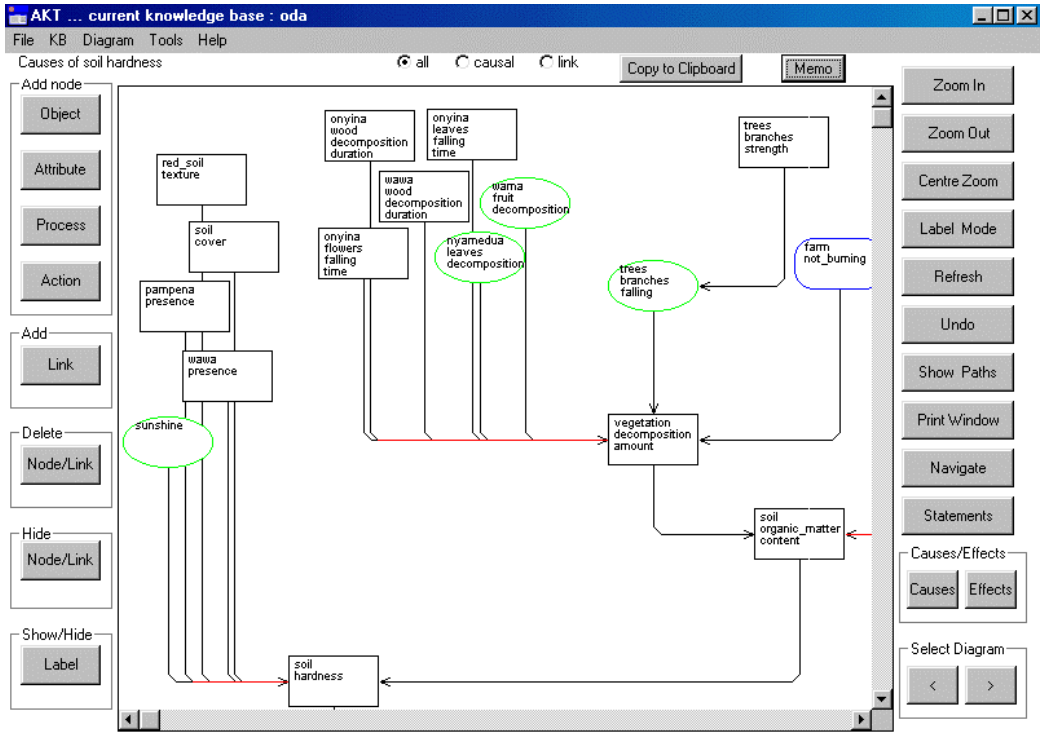
Closing AKT

To close AKT go to File → Exit from AKT

GLOSSARY: KEY TERMINOLOGY AND CONCEPTS FOR USING AKT

Action	A type of formal term used to refer to a process carried out by man for the purpose of managing his crops or livestock etc. for example: weeding, planting.
AKT	Agroecological Knowledge Toolkit: a methodology and software for creating knowledge bases.
Attribute	A type of formal term used to describe an object, process or action. Attributes are generally measurable e.g. height, colour, frequency, rate, gradient, temperature.
Boolean search	A keyword search mechanism for retrieving statements containing particular keywords. Any combination of words may be used in conjunction with 'and' and 'or'.
Causal statement	A statement about the causal relationship between two objects, processes or actions.
Comparison	A type of formal term used in comparison statements.
Comparison statement	A statement comparing the properties of two objects.
Control structures	When working with tools: program segments within AKT which control when and upon what knowledge primitives are used.
Data	A set of observations which may be quantitative or qualitative.
Diagram	A way of graphically representing causal and link statements.
Formal language	The restricted syntax (grammar) by which knowledge is coded into AKT.
Formal Term	Terms (words) - the key components in a formal language statement that do not belong to the formal grammar.
Knowledge	The outcome, independent of the interpreter, of the interpretation of data or information.
Knowledge base (Kb)	An articulated and defined set of knowledge stored on a computer which can be accessed and processed systematically.
Link	a) A type of formal term used in link statements. b) On a diagram – the connection between two nodes represented by an arrow.
Link statement	A type of statement used to represent knowledge that cannot be represented by any other type of statement.
Local knowledge	Knowledge based on locally derived understanding, formed by experience and observation.
Memo	A facility within AKT which provides additional explanatory information about a formal term, statement, diagram, topic or knowledge base.
Natural Language Statement	A statement which has been automatically translated by AKT from the formal language to a stylised English language translation.
Navigate	A command used when working with diagrams that adds to a diagram all the nodes immediately associated with a user selected node or statement.
Node	Causal and link statements can be represented on a diagram by two nodes connected by a link. Thus a node is the diagrammatic representation of one half of a causal or link statement which appears as a rectangular or circular box. There are four types of node: i) objects, ii) processes, iii) actions, and iv) attributes of either objects, processes or actions.
Object	A type of formal term used to refer to a material or conceptual thing e.g. pests, soil, cows, policy or household.
Object hierarchy	A way of organising knowledge about specific objects under more generic terms e.g. *Triplochiton scleroxylon, Milicia excelsa* and *Ceiba pentandra* are all types of tree.
Primitives	Small program segments within AKT employed for running a tool.
Process	A type of formal term used to refer to a change or flux in the real world e.g. decomposition, erosion.
Prolog (WinProlog)	An artificial intelligence programming language used for developing AKT software.
Source	The origin of the information contained in a statement. There are two types of sources: interview sources and reference sources.
Subobject (of an object)	An object falling below another object in an object hierarchy e.g. grass weeds may be a subobject of weeds.
Superobject (of an object)	An object above another object in an object hierarchy e.g. weeds may be a superobject of grass weeds.
Synonym	A word with the same meaning as a formal term, frequently used to specify the corresponding botanical name of a local name for a plant species.
Systems tools	Tools stored within AKT which can be used to interrogate and evaluate a knowledge base
Tool	A small computer program supplied with AKT that interrogates and reasons with the knowledge base.
Topic	A collection of statements organised around a particular subject e.g. Weed management and Grass weeds.
Topic hierarchy	A collection of topics organised under a broader subject area e.g. Weed management and Grass weeds both fall under the topic hierarchy Weeds.
User defined tools	Tools created by the knowledge base user that are stored separately to the main AKT program in a file with an .mcr extension.
Value	A type of formal term that is always attached to an attribute and describes that attribute e.g. 5kg, 20 ha, 3 months, yellow, tall, rapid.
WinAKT	The old name for AKT: Agroforestry Knowledge Toolkit for Windows.

DIAGRAM INSTRUCTIONS



Brief Description of the Buttons on left hand side of diagram window.

'Object'
'Attribute'
'Process'
'Action'
'Link'
These commands are only used when creating a knowledge base.

'Delete' Node/Link
'Hide' Node/Link
Allows user to hide a node or link on the diagram if necessary to increase clarity. Note underlying knowledge base is unchanged, and if diagram is redrawn the hidden links/nodes will be restored.

'Show/Hide' Label
Allows user to turn on / off the labelling for a selected link. Select the button, then press the 'mouse left button' down on the 'start' node and holding the button down, move to the 'end' node and release the mouse button (used to hide unwanted labels and improve clarity of the diagram).

Brief Description of the Buttons on right hand side of diagram window.

'Zoom In'
Allows more of the Kb to be seen on the diagram. (4 zoom levels)

'Zoom Out'
Reduces the area to be seen on the diagram. (4 zoom levels)

'Centre Zoom'
Click this button, place the mouse pointer over a node that you would like to appear in the centre of the diagram, and click once. The diagram will be re-positioned.

'Label Mode'
Clicks on this button will in turn :

1. display symbol information for all the links on the diagram.
2. display the stylised english labels for all the links on the diagram.
3. remove all symbols / link labels

'Refresh'
Refreshes the current window and returns any highlighted nodes to normal.

'Undo'
Will undo the last Navigate, Causes or Effects operation.

'Show Paths'
Will create a diagram showing all the possible paths between two or more highlighted nodes. The nodes can be highlighted by a right mouse double click over the node, and will turn green. Another double click will return node to normal.

'Print Window'
Prints a copy of the current diagram on the default system printer. The diagram will map onto either portrait or landscape mode. (Can also print to a file)

'Navigate'
Will display on the same diagram all the parent and child nodes of the selected node. Click 'navigate' then single click of the mouse on required node.

'Statements'
Produces a list of all the statements represented on the diagram.

'Causes'
After clicking 'Causes' button, position new cursor over a node and click l.h. mouse button. WinAKT will now redraw diagram showing all causal paths leading to selected node.

'Effects'
After clicking 'Effects' button, position new cursor over a node and click l.h. mouse button. WinAKT will now redraw diagram showing all the effects resulting from the selected node.

'Select Diag.'
Allows user to quickly move backwards or forwards through the current set of diagrams.

Dragging of nodes across the diagram.
Select any node by pressing the mouse left button down upon it,then holding button down, move to the new position. The progress of the node can be seen with a dotted node shape.

Resizing nodes on the diagram.
Select any node by pressing the mouse right button down upon it, then holding button down resize node as required. The new outline of the node is shown with a dotted outline

Show all links associated with a selected node.
Double click left mouse button on required node, and all statements associated with the node will be listed. Details of the statements can then be shown, deleted or printed.

Highlight a particular node.
Double click right mouse button on required node, and node will turn green. By selecting two or more nodes and pressing the 'Show Paths' button system will create another diagram showing all the possible paths between the two or more highlighted nodes. Another double click will return node to normal.

A QUICK SIGHTSEEING TOUR AROUND AKT

This quick tour around AKT with the Atwima knowledge base is designed to familiarise you with the AKT software and with ways of manipulating knowledge bases.

Getting started:

1. Load the AKT program (5.0) onto your computer by double clicking on the appropriate icon.
2. Open the atwima.kb by selecting **KB** from the menu at the top left hand side of the page and choosing **Open Kb…** Then select the atwima kb and click on **Open**.

Welcome Dialog Box

Read the Welcome dialog box to get an idea of what the knowledge base is about. Press **Further Details** to find out more about where, when and how the knowledge base was made. Click on **Pictures/Diagrams**. Read the text at the top and then view each picture by selecting it from the list, and then clicking on **Select**. When you have finished with each picture or diagram click on the X at the top right to close it. These diagrams provide some background information about the livelihoods of the farmers who provided the knowledge. The section of this folder 'Livelihood and land use diagrams' gives instructions for drawing them. Click on **Close** to return to the Welcome screen.

Press **Topics**.

Topic hierarchies

Topics are ways of organising information around particular subject areas e.g. 'Fallow length' or 'Weed management'. In ***topic hierarchies*** information about specific subject areas is arranged under a more general subject e.g. 'Fallow length', 'Fallow management' and 'Fallows and soil types' all fall under the general topic hierarchy of 'Fallows'.

On the left you can see a list of the topic hierarchies in the knowledge base. Highlight 'Soil types'. On the right you will see a column containing a list of all the topics in this topic hierarchy, to the right of this you will see 'Soil types' highlighted in blue and immediately below all the subtopics under it.

Click on **View Tree** and scroll down the page. This shows you the full topic hierarchy. Click on **Close**. Select 'Red soil in the 'Topics in hierarchy' list. You will see that it now appears in the 'Topic' box with 'Soil types' specified as the supertopic above it and 'Fallows on red soil' and 'Fertility of red soil' specified as the subtopics below it.

Highlight in turn each topic hierarchy listed in the Topic Hierarchies dialog box (on the left hand side of the screen).

Question: What topics does the topic hierarchy 'Weeds' cover?

Press **Close** on both dialog boxes to return to the Welcome Memo and Close again to arrive at the main menu.

Sources

Go to the main menu (top left) and select **KB** → **Sources…**

Sources tell you the origin of the information contained in a statement. All statements have a source, which can be of 2 types: an interview with a person e.g. a farmer or scientist, or a reference e.g. a journal reference.

On the left is a list of all the sources interviewed for the knowledge base. Let us look at one of them. Highlight the name 'Asmoah et al Kyereyase 2000a' and press **Details**. A dialog box appears giving you the name of the interviewers, interviewees and date of interview. You are also given the gender, age and ethnic origin of the interviewees and a location which is their town of residence. If you press **Memo**, you will be given any further details that the knowledge base creator felt to be important. Press **Close** on all three dialog boxes.

Topics

From the main menu select **KB** → **Topics…**

This gives you a list of all the topics in the knowledge base. Highlight **'Management actions'** and press **Details/Edit**. In the dialog box that appears you will see in the 'Boolean Search String' how the topic was created – it is a search for any of the following action words – 'burning', 'clearing', 'cutting', 'harvesting', 'planting', 'uprooting', 'use', 'work'. Click on **Show use in statements** at the bottom of the dialog box and a list of all the statements on management actions will appear. There are 107 statements in all. As you scroll through the list of statements you will notice that the translation does not sound like natural use of English - this is illustrated and explained in the section introducing you to diagrams below. **Close** the list of statements and the topic details.

Try the same thing with the topic **'Weed control'**.

Question: How many statements are there on weed control?

All knowledge in the knowledge base is represented through *statements* - these are the basic units of the knowledge base. There are 4 different types of statement. ***Attribute statements*** tell you about the properties (attributes) of something – they are descriptive. ***Causal statements*** give you information about causal relationships. ***Comparison statements*** compare the properties of two objects. ***Link statements*** represent knowledge that cannot be represented by the other types of statements.

You can see that 107 is a large number of statements to look through. We will now continue to look at smaller collections of knowledge. **Close** all open dialogue boxes and return to the main menu.

Object Hierarchies

From the main menu select **KB** → **Object Hierarchies…**

What we refer to as ***objects*** are words used to refer to material or conceptual things e.g. pests, soil, cows, policy, household. ***Object hierarchies*** are another way of sorting knowledge by arranging specific objects under more general objects e.g. *esa, funtum* and *onyina* are all types of trees. *Esa*, *onyina* and *funtum* are all therefore subobjects of the object 'trees', or alternatively, 'trees' is a superobject of the objects *esa*, *onyina* and *funtum*. Object hierarchies are, therefore, similar in structure to topic hierarchies.

On the left you can see a list of the object hierarchies in the knowledge base. Highlight 'trees'. On the right you will see a long column containing a list of all the objects in the hierarchy, to the right of this you will see 'trees' highlighted in blue and immediately below all the subobjects under it.

Click on **View Tree** and scroll down the page. This shows you the full object hierarchy, trees. Click on **Close**. Select 'timber tree' in the 'Objects in Hierarchy' list. You will see that it now appears in the 'Object' box with 'trees' specified as the superobject above it and odum, okoro, opam, wawa specified as the subobjects below it. Now **Close** all dialog boxes.

Formal Terms

Go to the main menu and select **KB** → **Formal Terms…**

Formal terms are the key components of statements. ***Objects*** are one type of formal term. Other types include ***actions*** – activities with a human agent e.g. harvesting or planting, and ***processes*** – activities without a human agent e.g. decomposition or germination. You will notice that underscores e.g. asase_tuntum, are used instead of spaces in the AKT program. Words which require a capital letter are put in brackets e.g. 'Chromolaena odorata'.

Press the downward arrow on 'Type' next to the word 'all' to see the different types of formal terms. Select **object**. All the objects in the knowledge base are now listed. Scroll down and get an idea of the objects in the knowledge base. Highlight **asase_tuntum** and press **Details**. This tells you what asase_tuntum is – black soil.

Press **Show use in hierarchies**. You will see that asase_tuntum appears in the object hierarchy soil. Press **OK**.

Press **Show use in statements**. The 5 statements that appear are all the statements in the knowledge base that mention asase_tuntum. Under 'Diagram Selection Type' at the bottom of the dialog box press **All Statements**.

Introduction to diagrams

The diagram that you see before you will show you all the statements with asase_tuntum that can be represented diagrammatically.

Diagrams are a way of representing statements. However only causal and link statements can be represented on a diagram. One statement is represented by two ***nodes*** (a rectangular or oval box) connected by an arrow. The different colours and shapes of the boxes indicate different types of node – action, process, object and attribute nodes. The words written within the nodes are the key terms used in the statement.

Press the **Label Mode** button twice. This gives you the statements written on the diagram in full. You can make the statements more legible by dragging the nodes across the screen to separate them out. Alternatively you can drag the statements themselves around the screen.

Question: What is the effect of cropping asase tuntum for 6 years?

If you want to find out what is meant by cassava_mix, click on the **Statements** button on the right to get a list of all the statements represented on the diagram. Then select statement 93 and click on **Details**. At the top of the dialogue box you will see the natural language statement and at the bottom its formal language equivalent.

Statements are typed into the knowledge base as ***formal language statements*** using a formal grammar (like a code) specific to AKT. These are then translated by the AKT program into stylised ***natural language*** equivalents. This use of computer generated translation explains why some statements in the knowledge base do not sound like natural English use.

Click on **Formal Terms**, select 'cassava_mix' and click on **Details**. An explanation is given here. **Close** all the dialogue boxes and return to the diagram.

When working with complex diagrams it is helpful to remember to switch the label mode off. Turn the label mode off now by clicking once more on **Label Mode**. Click on **Navigate** on the right hand side of the screen and then click on the node, 'fallow length'. (The Navigate button gives you the immediate causes and effects of each node). 'Fallow length' will be highlighted in green and some additional nodes will appear connected to 'fallow length. Carefully drag sideways all new nodes to reveal any further nodes underneath (by pressing the left hand mouse button over the node and dragging the node away). The red lines indicate that there is more than one line or arrow on top of one another. Click the **Navigate** button again and click on 'soil cocoa_suitability'. More nodes appear. Continue to build up the diagram by selecting **Navigate** each time and clicking on one of the new nodes.

When you have finished, go to the main menu (top left hand corner) and select **Diagram** → **Hide Diagrams**.

Boolean Search

Go to the main menu (top left). Select **KB** → **Boolean Search**. Go to 'Display KB terms of type' and click on the downward arrow to select 'object'. Select asase_kokoo'. Press **Details** to see the term's synonym and then press **Close** on the Formal Term Details dialog box.

Now press **Select** and 'asase_kokoo' will appear in the Boolean Search String at the bottom of the dialog box. Then press the **AND** button. Highlight 'asase_tuntum' and press **Select** once more. (If you want to check the synonym for 'asase_tuntum', press **Details**.) Press **Search**. Two statements will appear. These are the only statements in the knowledge base which include both 'asase_kokoo' and 'asase_tuntum'.

In the Search Results dialog box press **Close**. In the Boolean Search dialog box press **Clear**. Now do the same thing again, selecting 'asase_kokoo' and 'asase_tuntum', only this time using **OR** instead of AND. Press **Search**.

Now you have 30 statements. This is because you have selected all the statements that include *either* 'asase_kokoo' *or* 'asase_tuntum'.

In the Search Results dialog box press **Close**. In the Boolean Search keep 'asase_kokoo or asase_tuntum' in the Boolean Search String but this time select 'superobject' in the 'Search Options' box so that it is highlighted in the same manner as 'object'. Press **Search** once more. You will now have 157 statements because, besides statements using 'asase_kokoo' *or* 'asase_tuntum' you have also selected the statements related to the superobject of 'asase_kokoo' and 'asase_tuntum' i.e. 'soil'.

Closing a knowledge base and finishing off

Close the knowledge base by selecting **KB** → **Close KB…** and close AKT by going to the main menu **File** → **Exit from AKT**.

SOIL FERTILITY: FARMERS' CONCEPTS

This section will use the Oda knowledge base from the Wassa Amenfi district to examine farmers' knowledge of :

- Soil properties that change over time
- Different types of soil found at different locations in the landscape.

Farmers at the five field locations used a number of different terms to refer to soil fertility:

Twi	***English translation***
Asase okyene adee	Land that is good for crop growth/fertile
Asase a enyine	Land that is well grown (has had a lot of vegetation on the fallow)
Ahooden	Strength
Seradee	Fat
Asase mu seradee/ ahooden asa	The fat/strength in the land is finished
Ahooden fofro aba mu	New strength has come into (the land)

For further details refer to: Frost 2000; Moss 2000a and b; Obiri-Darko *et al*., 2000[1]

i. Load or select the Oda knowledge base.
ii. Go to **KB** → **Formal Terms…**
iii. Scroll down the list of terms until you come to 'fertility'. Highlight 'fertility ' and click on **Details**. Read the definition and synonyms.

It became apparent during the research that farmers have an aggregate concept of soil fertility. They frequently associate fertile soil with soil that has a high organic matter content and refer to fertile soil as land that crops grow and yield well one. This was sometimes confusing as e.g. land that is good for rice is not good for cocoa and vice versa. Fertile soil is also associated with land that requires little weeding.

Although farmers hold an aggregate concept of soil fertility they are aware of the following:

- Soil texture
- Soil moisture
- Soil fertility (meaning soil nutrients or else aggregate soil fertility – it was sometimes difficult to distinguish between the two)

[1] **Frost, W. 2000**. Farmers' knowledge of soil fertility and weed management in Atwima district, Ghana: The implications for participatory technology development. Unpublished MSc. Thesis. University of Wales, Bangor. 91 pp.

Moss, C., 2000a. Livelihoods and local knowledge of soil fertility management in peri-urban Kumasi, Ghana. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 24pp.

Moss, C., 2000b. Livelihoods and local knowledge of soil fertility management at Oda-Kotoamso, Wassa Amenfi District, Western Region, Ghana. School of Agricultural and Forest Sciences University of Wales, Bangor, UK. 38pp.

Obiri-Darko, B., Ayisi-Jatango, J., Anglaaere, L., Cobbina, J., Moss, C., McDonald, M., Sinclair, F., and Young, Einir., 2000. Livelihood systems and farmers ecological knowledge in Ghana: a report on three districts. Shortened Bush-fallow Rotations for Sustainable Livelihoods in Ghana (DFID Project R7446). School of Agricultural and Forest Sciences University of Wales, Bangor, U.K.

SOIL FERTILITY

iv. **Close** the two formal term dialogue boxes and go to **KB** → **Topic hierarchies…**
v. On the left, select the hierarchy 'Soil properties'.
vi. On the right, select the topic 'Soil fertility' and click on **Topic Statements**.

Looking through the statements we find knowledge about the following subject areas (the statements have been rearranged to make them easier to read):

1. Soil fertility indicators

There are 2 statements about how farmers tell if soil is fertile or infertile:
The statement numbers (e.g. 4 and 5) refer to the statement number in the knowledge base.

4: the soil fertility is fertile if
- the topiah leaves colour is green and the topiah leaves size is broad or
- the adupren leaves colour is green and the adupren fruit size is big or
- the clearing of land amount is complete and the burning of land amount is complete and the topiah presence is sparse or
- the asogyere presence is a_lot or fertility indicator presence is positive

5: the soil fertility is infertile if
- the topiah leaves colour is yellow and the topiah leaves size is small or
- the growth of topiah amount is stunted or
- the adupren fruit size is small or the adupren leaves size is small or
- the infertility indicator presence is positive

vii. Select statement 4 and then click on **Details**.
viii. Click on **Formal Terms**. Select 'adupren' and click on **Details**. You will now find out what *adupren* is. Press **Close** and then repeat with the other plant names that you are unfamiliar with.
ix. The last part of statement 4 refers to 'fertility indicator', and if we click on **Details** for this word, and then on **Show use in hierarchies** we see that it is a member of a hierarchy of the same name. Go to **KB** → **Object hierarchies…** and from the left select 'fertility indicator'.
x. Look at the other members of this hierarchy by selecting the plant name and clicking on **Object Details**. Then look at statement 5 in the same way.

Farmers use plant growth and the presence of particular plant species as indicators of fertile soil.

Topiah (*Chromolaena odorata*) is the most prevalent weed and fallow species in the forest and transition zones of Ghana. To find out more about farmers' knowledge of this species do the following:

xi. Return to the information about the formal term, 'topiah', and click on **Show use in statements**. A further list of statements appears.

From these statements it becomes clear that *topiah*, as a species capable of spreading rapidly onto an abandoned fallow, aids rapid regeneration of the land. However its persistence increases the frequency of weeding necessary on land that has been fallowed for less than 6 years.

2. Factors influencing soil fertility

Close all unnecessary dialogue boxes and return to the topic statements for 'Soil fertility'. A number of the statements in this topic refer to factors that influence soil fertility:

19: an increase in duration of continuous_cropping of land causes a decrease in fertility of soil
69: application of inorganic_fertiliser causes an increase in fertility of soil
20: decomposition of Gliricidia_sp. leaves causes an increase in fertility of soil
21: decomposition of Leucaena_sp. leaves causes an increase in fertility of soil
22: decomposition of Acacia_sp. leaves causes an increase in fertility of soil
151: cultivation of cowpea causes an increase in fertility of soil
40: an increase in content of soil organic_matter causes an increase in fertility of soil
104: the fallow maturity is mature causes the soil fertility is fertile
91: upland surface_runoff soil causes a decrease in fertility of upland soil
92: upland surface_runoff soil causes an increase in fertility of lowland soil
153: the asase_tuntum texture is loose causes the soil fertility is fertile

Farmers are aware that :

- Leguminous tree and crop species increase soil fertility but do not know about the mechanisms involved.
- Decomposition of organic matter increases soil fertility.
- Erosion on sloping land depletes the upper slopes, but adds fertility to lower slopes.

3. Influence of soil fertility

Other statements refer to factors resulting from an increase or decrease in soil fertility:

3: the replanting of cassava frequency is 3 times if the soil fertility is fertile
196: a decrease in fertility of soil causes an increase in duration of fallow
13: the soil fertility is infertile causes a decrease in yield of crop
68: an increase in fertility of soil causes an increase in amount of growth of crop
14: the soil fertility is infertile causes grass growth weeds
45: the soil fertility is infertile causes an increase in amount of growth of nsensan
52: the soil fertility is infertile causes the growth of plant amount is stunted

- Increased soil fertility results in improved plant and crop growth and yields.
- Infertile soil results in stunted plant growth and more weeds, particularly grass weeds.
- Farmers' actions are also influenced by soil fertility, cassava can be cropped for longer on fertile soil, on infertile soil farmers leave the fallow for longer.

xii. To view all the statements in the topic 'Soil fertility' on a diagram click on **All Statements** at the bottom of the list of topic statements for 'Soil fertility'. Drag the nodes (boxes) around to view them all clearly. You can use the **Zoom In** and **Zoom Out** buttons on the left to help you to see and rearrange all the nodes. Click twice on **Label Mode** to view the statements next to the nodes. These labels can also be dragged around to make them easier to read.

xiii. Alternatively go to **Diagram** → **Show Kb Diagrams** highlight '101', 'Soil fertility' and click on **Select**. You will then see a diagram of the topic 'Soil fertility' where the nodes and labels have already been rearranged.

4. Different types of soil

Hide the diagrams by going to **Diagram** → **Hide Diagrams**. Then return to the list of statements for the topic 'Soil fertility'.

204: the fertility of asase_fufuo is greater_than red_soil if the asase_fufuo texture is muddy
209: the fertility of asase_tuntum is greater_than asase_fufuo
211: the fertility of asase_tuntum is greater_than red_soil

- Farmers are aware of the relative inherent fertility of different types of soil. We will explore this in more detail next.

SOIL TYPES

i. **Close** all open dialogue boxes and go to the topic hierarchies menu (**KB → Topic hierarchies…**). Select 'Soil types'. You will see that there are 7 topics in the hierarchy.
ii. Click on **Topic Details** and you will see that the topic consists of all subobjects of soil.
iii. Go to **KB** → **Object hierarchies** and then select 'soil'. You will see all the different types of soil in the hierarchy. Click on **View Tree**.

- During the fieldwork farmers did not exhibit any standard system of referring to different types of soils in the area. Soils were referred to according to their most important distinguishing feature.

iv. **Close** the tree. Then view more detail for asase_fufuo and asase_tuntum by selecting the type of soil and clicking on **Object Details**.
v. **Close** all unnecessary dialogue boxes and return to the topic hierarchy soil. Select each topic in turn and view its **Topic Statements**.

1. Knowledge of upland and lowland soils

On upland:

- Drying out of the soil is a concern due to the sunshine it receives in its exposed position and to surface runoff.
- Surface runoff not only diminishes soil moisture availability but also contributes to a decline in fertility.

On lowland:

- Moisture is abundant due to the protection offered by the shade of the surrounding hills, and surface runoff from the uplands.
- However waterlogging can be a problem after heavy rain.
- Surface runoff contributes to the fertility of lowland soil.

Soil surveys carried out in this area have found that lowland alluvial soils around the Tano and Totua rivers are more fertile (in this case, have greater nutrient availability) than the upland soils. Farmers' observations demonstrate that they are aware of the moisture limitations of different soils, but the small number of observations about soil nutrients show that their understanding and ability to disaggregate in this respect is more limited.

2. Black soil, red soil and sandy soil

Black soil is

- More fertile than other types of soil (asase fufuo and red soil).
- It can be either sandy or clayey in texture:
  - Where it is clayey moisture availability is limiting,
  - Where it is sandy water infiltration and availability are high. It is also considered more fertile when this occurs.

Red soil

- Is sometimes gravely,
- Generally has a high clay content causing cracking when dry and limiting moisture availability, but where the subsoil is black or loose, moisture availability is high,
- Heats up less than asase fufuo and generally exhibits better moisture retention than the latter, but is less fertile than asase fufuo when the latter is muddy.

Sandy soil is

- Loose in texture causing drainage to be rapid, water retention low and it to become hot with the sun shining on it. However where it is muddy water retention is high.

Farmers' differentiation of the types of soil in the area was based on their topographical position and colour. Farmers referred to different types of soil based on their most important distinguishing characteristic rather than using a systematic classification. Farmers gave broad descriptions of different types of soil but also recognised that these were locally variable.

3. The subsoil

Farmers are aware of the lower layers of the soil. Hard clayey or rocky subsoil limits the potential of land use for cocoa. Where continuous cropping has taken place gravel becomes exposed.

Farmers are aware of the different properties of different soil types with regard to soil texture and moisture availability and make some observations about the relative fertility of the different soils. Their observations about the subsoil in the area are prompted by the fact that cocoa is the most important crop, and although the alluvial soils of the area are relatively suitable for it, some of the upland soils are more marginal. Although farmers are able to explain some aspects of plant growth in terms of soil structure, depth, moisture or fertility, they claim that some areas of their knowledge are lacking, for instance they cannot explain why crops sometimes do not do well on an area that has just been cleared from a well developed forest, or why cocoa will sometimes thrive on a soil on which plantain does not. They have virtually no knowledge of soil acidity which is an important limiting factor to crop growth at Oda, or of soil pests.

SOIL TEXTURE

i. Return to the list of topics under the soil properties hierarchy. Select 'Soil texture' and click on **Topic Statements**.

ii. All these statements are causal statements (you can see this by clicking on **Numerical**, after which the statements will be listed according to type). View the statements on a diagram by clicking on **All Statements** or alternatively, by going to **Diagram** → **Show KB Diagrams**, clicking on '103' for 'Soil texture' and then **Select**. A diagram of these statements that has already been arranged will appear. You may use the **Label Mode** button on the left to view the full statements or to turn the labels off.

- Looking at the diagram it becomes apparent that farmers perceive that the presence of trees, the type of soil, the presence of organic matter, soil cover and sunlight all have an influence on how hard or soft the soil is.

iii. To view more about the factors which have an indirect influence on soil texture click on **Statements** on the right hand side of the diagram. A list of the statements represented on the diagram will then appear. Click on **Most** (connected node) on the right hand side of the page. A new diagram will then be drawn showing the node with the most connections – in this case 'soil hardness', highlighted in green. The direct causes of soil hardness are shown on the diagram. To explore the indirect causes click on **Causes** (bottom, right) and then click on the node 'soil hardness'. A number of additional nodes will appear which will require rearranging. Once you have rearranged your diagram you can continue to explore causal links by clicking on **Navigate** and then clicking on the node you want to explore.

SUMMING UP

- Farmers have an aggregate concept of soil fertility at Oda.
- However texture, moisture availability and fertility are important properties that are distinguished.
- Farmers use plant growth and the presence of particular plant species as indicators of fertile soil.
- Farmers view weeds and soil fertility as closely related.
- Farmers view some plant species as playing both positive and negative roles – *Chromolaena odorata* is viewed positively as a species that grows rapidly on the fallow shading out other weeds and producing a lot of biomass, but on crop land it is a persistent weed.
- Soil fertility is closely related to soil organic matter content.
- Areas where farmers' knowledge is particularly sparse are
  - Soil pests,
  - Soil acidity and
  - Causal processes that indirectly influence soil fertility such as the mechanisms by which leguminous plants add nitrogen to the soil.
- Farmers know that the presence of some tree species on crop land enhances soil properties whereas other species have a negative effect.
- Farmers differentiate between different types of soil based on colour and location and are aware of their potential for crop growth.

WHAT DO PERI-URBAN FARMERS KNOW ABOUT INORGANIC FERTILIZER?

Farmers in peri-urban Kumasi use inorganic fertilizers for the commercial production of vegetables, rice and occasionally maize for cash sale. They have also been taught by extension agents about using fertilizer on plantain, and have experimented with this.

FARMERS' KNOWLEDGE OF THE USE OF INORGANIC FERTILIZER

i. Load or select the peri-urban kumasi kb.
ii. Go to **Kb → Topic hierarchies…**
iii. Select 'Soil fertility management' from the menu on the left.
iv. On the right, under 'Topics in hierarchy' select 'Inorganic fertilizer'
v. Click on **Topic Statements**. Browse all the statements about farmers knowledge of inorganic fertilizers.

Looking through the statements it becomes apparent that farmers have knowledge of the following subjects:

1. Type of fertilizer

The two main types of fertilizer readily available at the time of the research were compound fertilizer 15:15:15 NPK and sulphate of ammonia (referred to as 'ammonia'). Ammonia is used for top dressing rice and at flower set stage of garden egg and other vegetables. A number of other fertilizers are available in Kumasi e.g. Phostrogen, but knowledge of these was not expressed by the interviewees.

101: application of ammonia causes the rice leaves colour is green
118: application of ammonia causes an increase in amount of setting of garden_egg flowers
166: application of ammonia causes an increase in size of fruit
168: the application of ammonia amount is excess causes rotting of fruit
220: the duration_of_work of compound_fertilizer is greater_than ammonia

2. Application of fertilizer

Only farmers who had used fertilizer could talk about application rates. These were generally dictated by what farmers could afford at the time of fertilizer purchase, by their own experimentation and by the appearance of the crop (e.g. yellow leaves) and farmers' perception of the initial fertility of the soil. Farmers frequently could not specify how much fertilizer they used. Work done in the Brong Ahafo region found that vegetable farmers' practices were highly variable with some farmers applying recommended rates, others applying far more than recommended rates and others applying far less (Awiti *et al.*, 2000[1]). Nevertheless farmers in peri-urban Kumasi were aware of the dangers of using too much fertilizer or applying it without water:

93: the application of inorganic_fertilizer amount is excess causes go_to_seed of cabbage
120: the application of inorganic_fertilizer amount is excess causes crumbling of crop leaves
168: the application of ammonia amount is excess causes rotting of fruit
136: application of inorganic_fertilizer causes death of crop if no_rainfall
105: application of inorganic_fertilizer causes the crop leaves colour is yellow_with_black_spots if no_rainfall

3. Crop growth

42: the soil fertility is infertile causes the growth of crop amount is stunted if no_application of inorganic_fertilizer
60: application of inorganic_fertilizer causes the crop leaves colour is green if the crop leaves colour is yellow
61: application of inorganic_fertilizer causes the growth of crop amount is good if rainfall
82: application of inorganic_fertilizer causes the growth of crop rate is very_fast
101: application of ammonia causes the rice leaves colour is green
119: application of inorganic_fertilizer causes an increase in amount of spreading of crop

4. Yield

62: application inorganic_fertilizer vegetables causes the fruit size is big
72: application of inorganic_fertilizer causes an increase in yield of crop
81: application of inorganic_fertilizer causes an increase in number of plantain suckers
85: application of inorganic_fertilizer causes an increase in size of plantain finger
86: application of inorganic_fertilizer causes an increase in size of maize cob
166: application of ammonia causes an increase in size of fruit

With regards to crop yield farmers emphasized the size of vegetables and maize cobs rather than the overall quantity harvested (which is more difficult to calculate), except in the case of plantain suckers which form a source of income through sale to other farmers.

5. Palatability of tubers and vegetables

167: application of inorganic_fertilizer causes a decrease in palatability of vegetables
187: application of inorganic_fertilizer causes a decrease in palatability of cassava
202: application of inorganic_fertilizer causes a decrease in palatability of plantain
188: application of inorganic_fertilizer causes a decrease in palatability of cocoyam

Farmers recognized that fertilizer application decreased the palatability of tubers and vegetables. This is best known in the case of cassava where fertilizer application affects the quality of the cassava for fufu.

6. Vegetable shelf life

83: application of inorganic_fertilizer causes a decrease in shelf_life of garden_egg fruit
94: application of inorganic_fertilizer causes a decrease in shelf_life of cabbage

7. Other factors

Farmers are also aware that using fertilizer influences the effect of pest attacks:

172: application of inorganic_fertilizer causes a decrease in amount of plantain base damage termites
174: application of inorganic_fertilizer causes the soil temperature is cool

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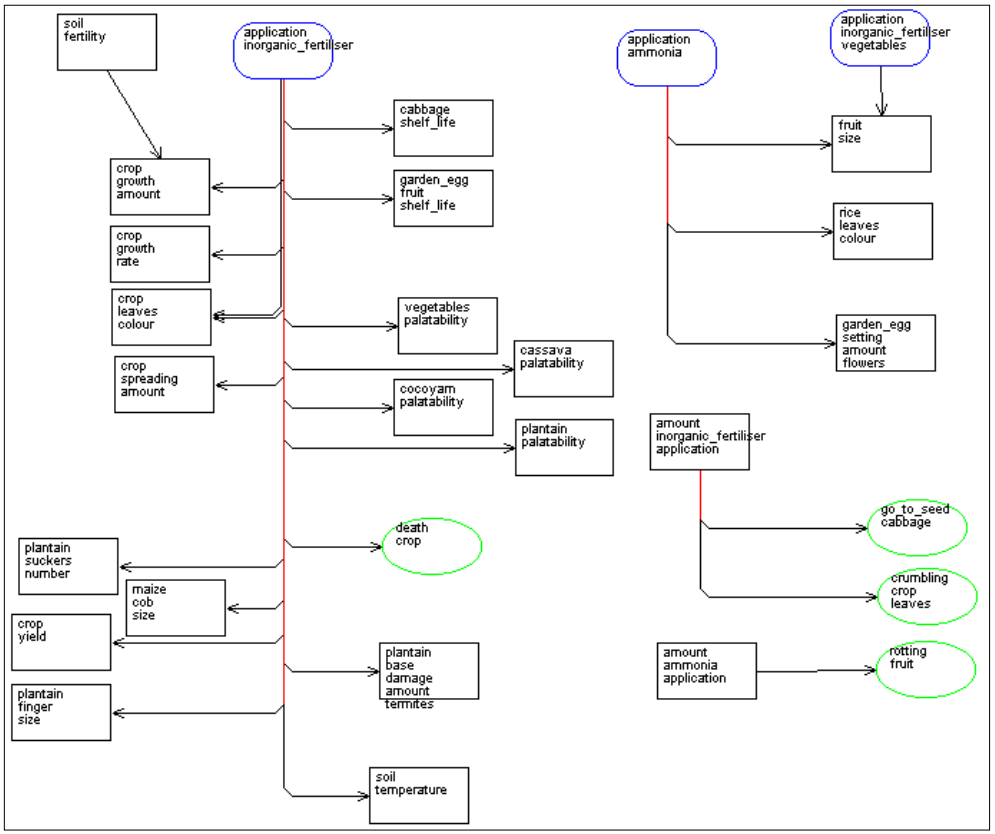
1 **Awiti, S., Binney, K., Chan, M.K., O'Connell, N., Jackson, D., Kiff, E., and Nelson D., 2000** Improved Vegetable Production in the Forest-Savanna Transition Zone, Ghana with special reference to the maintenance of soil fertility. Natural Resources Institute, University of Greenwich/ Ministry of Food and Agriculture, Brong Ahafo region, Ghana.

The final statement 174 illustrates farmers' use of terminology for talking about productive soil. Farmers associate soil that is good for plant growth with soil that has a high organic matter content which is thus cool in temperature. This way of referring to soil as 'cool' is hence transferred to soil that is good for plant growth because fertilizer has been applied.

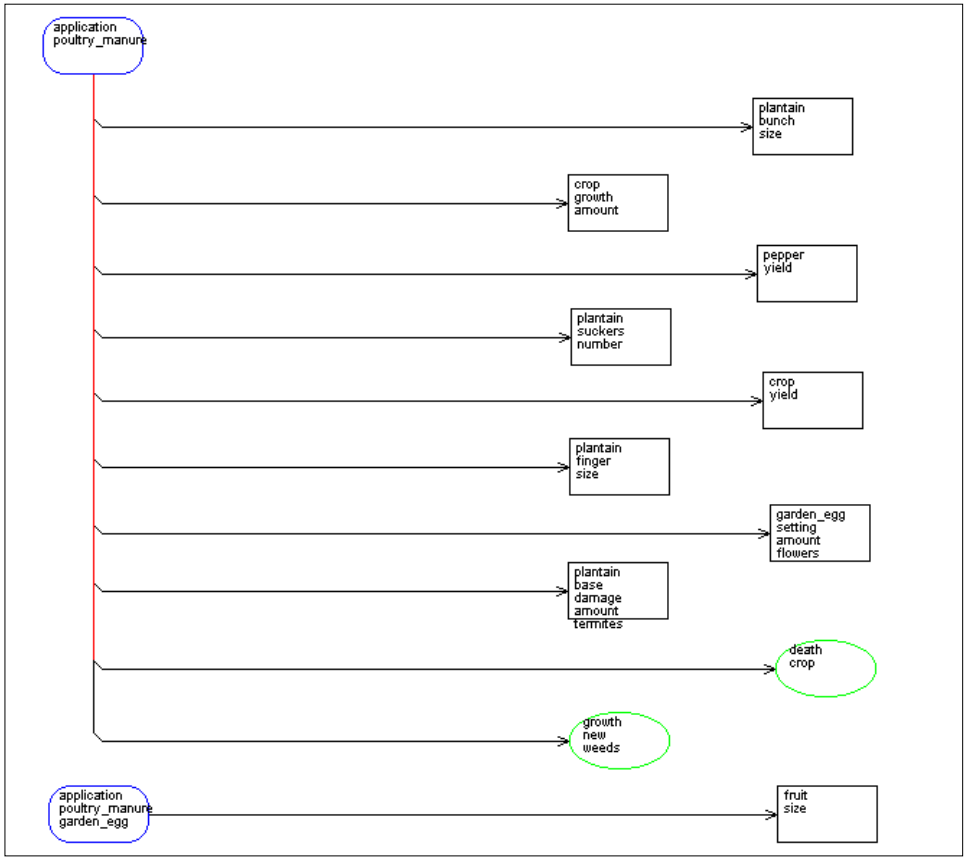
vi. To view all the causal statements on a diagram click on **All Statements**. You can rearrange the diagram by dragging the nodes (boxes) around. Alternatively go to **Diagram** → **Show Kb Diagrams**, select '120' 'Inorganic fertilizer' and click on **Select**.

Diagram representing statements from the topic: Inorganic fertilizer (the nodes have been rearranged by dragging them around the diagram)



vii. When you have finished, hide your diagram by going to **Diagram** → **Hide Diagrams**. **Close** all open dialogue boxes and return to the main menu. Then follow the same procedures for the topic 'Poultry manure'.

Diagram representing statements from the topic: Poultry manure (the nodes have been rearranged by dragging them around the diagram)



SUMMING UP

- Farmers in peri-urban Kumasi use inorganic fertilizers on cash crops.
- Quantities applied are dependent on the fertility of the soil, farmers' cash constraints, information from other farmers and extension agents, and their own experiments with different quantities.
- Farmers emphasise the size of fruit when referring to the effect of the fertilizer on crop yield.
- They are unlikely to apply fertilizer to root crops such as cassava and cocoyam because they perceive a decrease in palatability as a result of doing so. Poultry manure is however, considered to have a lesser effect on palatability. Farmers are satisfied with the use of fertilizer on plantain but cannot justify the cost of application over large areas.
- Farmers remain unaware of potential long term negative effects of continued use of inorganic fertilizers on soil structure or acidity but they have some perception that fertilizer can influence the effect of pest attacks.

FALLOWING AND SOIL FERTILITY

Fallowing is the traditional and frequently the only means of restoring soil fertility in the forest and transition zones of Ghana. Agricultural scientists frequently consider fallowing to be an outdated and destructive practice and would like farmers to practise more sedentary agriculture. However, uptake of more sedentary farming systems is slow and consideration of farmers' knowledge concerning fallowing may suggest reasons why.

This exercise will examine farmers' knowledge of fallowing in Atwima district in the Ashanti region.

i. Open or select the Atwima knowledge base.
ii. Go to **Kb** → **Topic hierarchies…**
iii. Select 'Fallows' in the box on the left.

THE DURATION OF THE FALLOW

iv. From the box on the right, select 'Fallow length' and click on **Topic Statements**

You will find that 28 statements appear. By examining the content of the statements it can be seen that they fall under the following headings:

1. Fertile soil and the duration of the fallow on different soil types

55: the fallow length is short causes a decrease in fertility of soil
66: the fallow length is 5 years causes the density of earthworm is high
71: the fallow length is in the range 8 years to 10 years causes the black_layer depth is 15cm
387: an increase in length of fallow causes an increase in fertility of soil
73: the fallow length is in the range 15 years to 20 years causes the fertility of soil is high if the afonywie presence is positive
84: the fallow length is in the range 5 years to 10 years causes the fertility of soil is high if the asase_kokoo presence is positive or the asase_tuntum presence is positive
85: the fallow length is 6 years causes the fertility of soil is high if the ateche presence is positive

v. Select statement 73 and click on **Details**. Click on **Formal Terms**, select 'afonywie' and click on **Details**. You will see that this is a sandy loam soil. **Close** the 3 dialogue boxes. Repeat this procedure for statement 84 with 'asase_kokoo' and 'asase_tuntum' and for statement 85 with 'ateche'.

- Generally farmers recognise the longer land is left to fallow, the greater the fertility of the soil, and refer to the build up of organic matter in the topsoil and the presence of earthworms.
- Farmers know that different types of soil require different periods of time to regain high levels of fertility:
  - *Afonywie* requires 15 to 20 years.
  - *Asase kokoo* requires 5 to 10 years.
  - *Asase tuntum* requires 5 to 10 years.
  - *Ateche* requires 6 years.

2. Crop growth and yields

52: an increase in length of fallow causes an increase in rate of growth of rice
276: the fallow length is 2 years causes the crop yield is average if the asase_kokoo presence is positive
283: the fallow length is 3 years causes the crop yield is average

- Farmers can achieve a satisfactory yield on fallows that are shorter than those that are required to return soil to 'high' levels of fertility.

3. Weeds

5: the nyanya appearance is first if the fallow length is long
60: the fallow length is >1 year causes a decrease in density of esre seed
61: the fallow length is 5 years causes a decrease in density of acheampong if the asase_kokoo presence is positive
179: clearing of fallow causes the presence of weeds seed is high if the fallow length is not >5 years
270: the fallow length is 1 year causes an increase in rate of growth of weeds
272: an increase in length of fallow causes a decrease in strength of weeds

vi. If you do not know what esre is, select statement 60 and click on **Details**. Click on **Formal Terms**, select '*esre'* and click on **Details**. You will see that '*esre'* is the grass *Panicum maximum*. **Close** the dialogue boxes and repeat the procedure to find out what *acheampong* is in statement 61.

- Although farmers are satisfied with the crop yields that they obtain, weeds are more of a problem after a short fallow. *Panicum maximum* (*esre*) is a problem on very short fallows, and *acheampong* (*Chromolaena odorata*) on fallows of less than 5 years.

vii. Statement 5 mentions *nyanya.* Select statement 5 and click on **Details**. Click on **Formal Terms**, select '*nyanya'* and click on **Details**. *Nyanya* is a weed that appears before other weeds on crop land if the fallow has been long. Click on **Show use in hierarchies**. *Nyanya* is both a weed and an indicator of fertile soil. Click on **OK**. Click on **Show use in statements**. Examining the statements that then appear provides more information about *nyanya*. When you have read the statements return to the statements for the topic 'Fallow length'.

4. Fallow vegetation

41: a decrease in length of fallow causes a decrease in density of trees
59: the fallow length is in the range 5 years to 10 years causes the nfofoa_kwae presence is positive
68: the fallow length is in the range 8 years to 10 years causes the death of undergrowth proportion is 100%
101: clearing of kwae causes development of nfofoa_kwae if the fallow length is long

- Farmers are aware of the changes in vegetation on fallow land as abandoned farm land reverts to forest

5. Crops grown and cropping periods

62: the fallow length is 5 years causes the crop cropping_period is 2 years if the asase_kokoo presence is positive
63: the fallow length is in the range 8 years to 10 years causes the crop cropping_period is in the range 4 years to 5 years if the asase_kokoo presence is positive
138: the afonywie cropping_period is 1 year causes the fertility of afonywie is high if the fallow length is long
142: the afonywie cropping_period is in the range 2 years to 3 years causes the fertility of afonywie is low if the fallow length is long
367: the fallow length is in the range 7 years to 10 years causes the cocoa_suitability of soil is high if the asase_kokoo presence is positive
391: the fallow length is 2 years causes the growth of plantain rate is zero

- The duration of the fallow also influences the length of time the land can be cultivated. 4 or 5 years cultivation is possible after a fallow of twice that duration, whereas only 2 years is possible when the land has only been fallowed for 5 years.
- The duration of the fallow also influences the type of crops that can be grown. Cocoa and plantain require fallows of longer duration than other crops.

6. Soil pests

56: a decrease in length of fallow causes an increase in density of soil_pest
58: the fallow length is long causes the soil_pest presence is absent

- There are 2 statements in the knowledge base that show that farmers are aware of the influence of fallow length on soil pests, however farmers' knowledge in this respect is fairly minimal and lacks more specific information about the type of soil pests encountered.

viii. Return to the lists of statements for the topic 'Fallow length'. To view a diagram of all the causal statements click on **All Statements** at the bottom of the dialogue box. The diagram can be rearranged by dragging the nodes (boxes) around the page. To view a diagram that has already been rearranged in this way go to **Diagram** → **Show Kb Diagrams**. Select diagram '119', 'Fallow length' and click on **Select**.

ix. The diagram shows all the direct implications of fallow length. To explore more of the indirect influences through causal processes, click on **Effects** at the bottom right of the screen and then click on 'Fallow length'.

x. The number of nodes now increases and the diagram becomes more complicated. We are now going to explore the connection between 'fallow length' and 'weeds density' using the diagram. The node 'fallow length' is already highlighted in green. To find and then to highlight the node 'weeds density' click on **Statements** on the right hand side of the page. This will give you a list of all statements shown on the diagram. The first statement contains the words 'density of weeds'. Select this statement and then click on **Find** on the right. You will find two additional nodes highlighted for you on the diagram. Unhighlight the node 'crop yield' by double clicking on it with the right hand mouse button. Now only two nodes will be highlighted – 'weeds density' and 'fallow length' (although your diagram is rather large and you may not be able to see both at the same time on the screen). Now click on **Show Paths**. A new diagram is drawn which shows all the causal pathways between 'fallow length' and 'weeds density'. Rearrange the diagram to make the connections between the nodes clear.

- Farmers understand that trees on the fallow protect the soil from sunlight and shade out weeds. Longer fallows are more effective at shading out weeds.

CLEARING FALLOW LAND

The topic 'Fallow management' provides further information about fallows, weed growth and labour requirements.

xi. Return to the topic hierarchy 'Fallows' and this time select the topic 'Fallow management' and click on **Topic Statements**.

The list of statements produced can be arranged under the following headings:

1. Weed growth

185: the clearing of fallow season is harmattan causes a decrease in density of germination of weeds
186: the clearing of fallow season is harmattan causes the density of sprouting of weeds stump is low
187: the clearing of fallow season is rainy causes an increase in density of germination of weeds
188: the clearing of fallow season is rainy causes the density of sprouting of weeds stump is high
273: the fallow stage is mature causes the clearing of weeds frequency is 2
274: the fallow stage is not mature causes the clearing of weeds frequency is in the range 3 to 4

- The season when the fallow is cleared influences weed growth
- The type of vegetation on the fallow influences the number of times it is subsequently necessary to weed crops.

2. Ease of land clearing

438: the clearing_ease of fallow acheampong is greater_than fallow esre
442: the clearing_ease of fallow acheampong is greater_than fallow nfofoa_kwae

- It is easier to clear fallows dominated by *acheampong* (*Chromolaena odorata*) than those that are secondary forests or *esre* (*Panicum maximum*) fallows.

SUMMING UP

- Considerations of the time required to restore soil fertility during the fallow may be over estimated given that farmers can achieve average yields after short fallows.
- Short fallows may have a greater influence on weed growth than on crop yields. *Panicum maximum* is a problem on very short fallows, whereas *Chromolaena odorata* prevails on fallows of less than 5 years.
- Farmers grow different crops after shorter fallows than they would after longer fallows and are able to use land for a longer period after longer fallows.

TREES AND SOIL FERTILITY

Farmers recognise trees as important in the restoration of soil fertility during the fallow and for protecting the soil from drying out. They also recognise the influence of different species on soil moisture and soil fertility.

TREES

Farmers at all 5 sites recognised both negative and positive implications of having trees on farm.

i. Open the atwima.kb. Go to **KB** → **Boolean search**. Type in the word 'trees' and make sure 'object' is selected. Click on **Search**. A list of 42 statements appears.

ii. To draw a diagram, click on **All Statements** at the bottom of the page. Rearrange the nodes on the diagram so that they are all visible. (Alternatively go to **Diagram** → **Show Kb Diagrams** and select diagram '128', 'Trees').

iii. Look at the nodes, and if the meaning of the diagrammatic representation is unclear, double click on a node with the left mouse button and this will take you to the statements for that node.

- Farmers' knowledge in the atwima kb shows that the number of trees on farm is influenced by:
  - The length of the fallow,
  - The type of soil,
  - Management actions e.g. not cutting young and sprouting trees at the start of the fallow and
  - The presence of *Panicum maximum* which hinders colonisation of fallow land by trees.
- The presence of trees on the farm has both positive and negative effects:
  - Decreasing density of trees makes rainfall more erratic.
  - Decomposing leaves, fruit and logs increase soil fertility.
  - Trees shade the soil and make it cool (*enyunu*).
  - Trees cause a decrease in wind speed on farm.
  - Shading decreases the yield of mature cocoa trees but prolongs their life.
  - Trees shade out undergrowth and weeds – particularly *Chromolaena odorata* and *Panicum maximum* on the fallow.

iv. To explore the influence of the reduction in wind speed on farm caused by the presence of trees, click on **Effects** (bottom, right) and then click on the node 'wind speed'. Rearrange the resulting nodes.

- A decrease in wind speed reduces the likelihood of plantain being blown over, and the effectiveness of the dispersal of the seeds of acheampong (*Chromolaena odorata*).

v. Repeat iv. for other nodes on the diagram.

vi. Compare farmers' knowledge at Atwima with farmers' knowledge at Yabraso in Wenchi district by opening the yabraso knowledge base and doing a Boolean search for trees. Compare the results of your search from the yabraso.kb with that from the atwima.kb.

THE INFLUENCE OF DIFFERENT TREE SPECIES ON SOIL FERTILITY AND SOIL MOISTURE

Farmers at the five sites recognised the influence of different tree species on soil properties – predominantly soil moisture and soil fertility.

- To see what tree species are mentioned in the knowledge bases do the following :
  - i. Open all the local knowledge bases (atwima, oda, peri-urban kumasi, subriso and yabraso).
  - ii. Go to **Tools** → **Open Tool File…**
  - iii. Find the GhanaTools.mcr and click on **Open**.
  - iv. Scroll down the list of tools on the left, and select 'trees'.
  - v. Click on **Details**. Read the information in the 'Description' box at the top of the page. (You do not need to read or understand the information below it).
  - vi. In the dialogue box on the left click on **Run** and select 'List trees by scientific name'. Click on **OK**. You will then obtain a list of all the Latin names of trees in the knowledge bases. The tool output also tells you in which knowledge bases the different trees occur.
  - vii. To list the trees by local name, run the tool again, but this time choose the option 'List trees by local name'.
- To view the statements about the influence of tree species on soil moisture do the following:
  - viii. Go to **Tools** → **Tools** → User Tools → Ghana Tools → tree_species_search. This tool enables you to search for tree species within a set of topic statements.
  - ix. Click on **Run**, and when prompted to do so, choose the topic 'Trees and soil moisture availability'.
  - x. At the end you will obtain a list of statements for the topic 'Trees and soil moisture availability' and you will be told the number and names of the trees that appear in these statements. You will now have a list of statements that show the influence of individual tree species on soil moisture availability.

The table on the next page summarises farmers comments from the topic 'Trees and soil moisture availability' and the topic 'Trees and soil fertility'.

Farmers' knowledge of the influence of tree species on soil fertility and soil moisture. (The letters stand for the individual knowledge bases A = Atwima, O = Oda, P = Peri urban kumasi, S = Subriso, Y = Yabraso. '+' represents a positive influence and '-' a negative influence).

Tree species	***Local name***	***Soil moisture*** +	***Soil fertility*** +	***Soil moisture*** -	***Soil fertility*** -
Acacia_sp.	*Acacia*		O		
Albizia adianthifolia	*Pampena*			O	
Albizia ferruginea	*Aweamfosamena*		S		
Albizia spp.	*Okoro*			AOS	
Alchornea cordifolia	*Gyama*	P			
Alstonia boonei	*Nyamedua*	OS	O		
Antiaris toxicaria	*Kyenkyen*		S	O	
Bombax buonopozense	*Akonkodie*	OS			
Ceiba pentandra	*Onyina*	OS	A OP	Y	
Celtis mildbraedii	*Esa*			AO	
Cola gigantea	*Awapuo*			S	
	Watapuo				
Cylicodiscus gabunensis	*Denya*			O	
Daniellia oliviera	*Senya*	PY			
Ficus capensis	*Domini*	A	A		
Ficus exasperata	*Nyankyerene*	P		AOS	
Ficus spp.	*Doma*	A OPS	AY		
Funtumia elastica	*Funtum*	OPS		A	A
Gliricidia_sp.	*Gliricidia*		O		
Glyphea brevis	*Foto*		A		
Khaya spp.	*Mahogany*	OSY	S		
	Kwakwuedauba	S			
Lannea welwitschii	*Kumanini*		A		
Leucaena_sp.	*Leucaena*		O		
Mallotus oppositifolius	*Nnan_furo*			A	A
Mangifera indica	*Mango*	S			
Margaritaria discoidea	*Pepewa*	Y		S	
Milicia excelsa	*Odum*	PY		O	
Newbouldia laevis	*Sasamamsa*	O			
	Nworama	S			
Parkia biglobosa	*Srono*	Y			
Petersianthus macrocarpus	*Esia*	O			
Phyllanthus reticulatus var. glaber	*Awobe*	S			
Piptadeniastrum africanum	*Dahoma*			O	
Pterygota macrocarpa	*Keyja*			A	A
Rauvolfia vomitoria	*Kakapenpen*	S	A	A	A
Red odoma (Ficus spp./ Ficus capensis)	*Odoma kokoo*			A	
Ricinodendron heudelotii	*Wama*	OS	O		
Solanum erianthum	*Pepediawuo*		AS		
Spathodea campanulata	*Kokoanisua*	AS	A		
Terminalia ivorensis	*Emire*	OP			
Terminalia superba	*Ofram*	OS			
Trema orientalis	*Sesea*	S			
Triplochiton scleroxylon	*Wawa*	PY	O	OS	
Vitellaria paradoxa	*Kranku*	Y			

xi. Repeat steps viii to x but this time select the topic 'Trees and soil fertility'.

- Viewing the statements produced we see that farmers claim that particular tree species directly increase soil fertility as follows:

  - Some trees grow rapidly covering fallow land quickly: *ogyama*.
  - For some trees farmers did not explain how they increased soil fertility: *kakapenpen*, *foto*, *pepediawuo*, *kokoanisua*, Acacia_sp., Gliricidia_sp., Leucaena_sp., *aweamfosamena*, *kyenkyen*, *mahogany*.
  - The rapid decomposition of the flowers, fruit and woody parts of some trees adds to soil fertility: *domini*, *kumanini*, *odoma*, *onyina*, *nyamedua*, *wama*.

To find more information about an individual tree species across all the loaded knowledge bases do the following :

xii. Go to **Tools** → **Tools** → User Tools → Ghana Tools → term_search. Click on **Run**, and when asked to, type in the local name of the tree you wish to search for e.g. '*onyina*' (*Ceiba pentandra*). The tool then produces a list of statements for each knowledge base that contain this term.

- The following information about *onyina* is retrieved:

  - Farmers suggest that *onyina* increases soil fertility through the rapid decomposition of its woody parts and leaf and flower fall.
  - Branches are brittle and can cause crop damage (but add to soil fertility).
  - *Onyina* hosts capsids.
  - Shade provided by young trees is too dense, but that of taller trees is good for crop growth.
  - There is some contradiction concerning comments relating to soil moisture availability.

It is possible to search for statements under a common topic throughout all the loaded knowledge bases.

xiii. Go to **Tools** → **Tools** → User Tools → Ghana Tools → topic_hierarchies_common. Click on **Run**. Select 'Trees', click on **OK**, then select the topic 'Trees and soil fertility' and click on **OK** again. You will be presented with a list of statements for each knowledge base for the topic. Following each set of statements you also have the option of viewing the statements on a diagram. When all kbs have been searched a final output is provided which again lists the topic statements for each knowledge base.

The statements that are obtained through this search method give all knowledge about trees and soil fertility in general as well as knowledge about individual species.

COVER CROPS: LOCAL AND EXPERT KNOWLEDGE

The cover crops knowledge base was created to analyse knowledge transfer about cover crops in the Brong Ahafo region. Cover crop research in the forest and transition zones has been carried out by the Crop Research Institute and the Soil Research Institute in Kumasi, and the Sedentary Farming Systems Project and the Integrated Food Crop Systems Project in conjunction with the Ministry of Food and Agriculture in the Brong Ahafo region.

i. Open the cover crops kb. (Ignore the first message that appears and just click on **OK**).
ii. Read through what the knowledge base is about in the Welcome screen and under **Further Details**.
iii. Click on **Topics**, then select 'Mucuna' from the list of topic hierarchies on the right. View the different topics about mucuna by clicking on **View Tree** on the left.
iv. **Close** the Mucuna hierarchy tree. Then select the topic 'Sole cropping of mucuna' and click on **Topic Statements**.

The statements that appear are as follows:

55: the mucuna spacing is 80cm x 50cm if sole_cropping of mucuna or inter_cropping mucuna short_season_cereal
56: the weeding of mucuna time is in the range 2 WAP to 4 WAP if sole_cropping of mucuna
172: the Mucuna spp Rajada dry_matter accumulation is 4.4t/ha if the sole_cropping of mucuna location is northern_Guinea_savanna_zone
197: the weeding of mucuna frequency is twice if the sole_cropping of mucuna location is Ghana
198: the weeding of mucuna time is 1WAP if the sole_cropping of mucuna location is Ghana
199: the weeding of mucuna time is 4 WAP if the sole_cropping of mucuna location is Ghana
214: the mucuna plant spacing is 40cm x 40cm if sole_cropping of mucuna
351: the sole_cropping of mucuna time is major_season causes the mucuna dry_matter accumulation is in the range 3.2t/ha to 4.0t/ha if the mucuna location is transition_zone_of_Ghana and the growth of mucuna duration is 4 months
457: sole_cropping of mucuna causes the cover_cropping of mucuna results is best if the weed type is aggressive and the mucuna time_of_use is first
475: the weeding of mucuna frequency is once causes an increase in amount of establishment of mucuna if sole_cropping of mucuna
492: the application urea maize rate is 90kg/ha causes the subsequent_crop maize grain yield is 57% increase if control_treatment is maize_with_no_fertiliser and the sole_cropping of mucuna time is major_season and the sole_cropping of maize time is minor_season and the mucuna location is transition_zone_of_Ghana and the growth of cover_crop duration is 4 months
556: the application fertiliser mucuna rate is 45:18:18 kg NPK/ha causes the subsequent_crop maize yield is same if control_treatment is maize_with_recommended_dose_of_fertiliser and the sole_cropping of maize time is major_season and the mucuna location is transition_zone_of_Ghana
562: the sole_cropping mucuna researcher management is positive causes the subsequent_crop yield_increase is 100%
644: the subsequent_crop_grain_yield of mucuna is greater_than Canavalia ensiformis if the sole_cropping of cover_crop time is major_season and the cover_crop location is transition_zone_of_Ghana and the growth of cover_crop duration is 4 months

Reading through the statements there is the following knowledge:

1. Crop spacing

- Two statements suggest different spacing for planting mucuna as a sole crop (statements 55 and 214).

v. To find out the sources of these recommendations select statement 55 and click on **Details**.
vi. The source is given at the top of the dialogue box as 'MOFA, 2000 Ghana extension 2001a'. Click on **Sources**, select this source and click on **Details**. The recommendation comes from the Land and Water Management Unit of MOFA.
vii. **Close** the dialogue boxes and repeat the procedure to find out the source of statement 214.
viii. These are not the only recommendations for cover crop spacing in the knowledge base. Press **Close** (twice) to close the source information and return to statement 214. Click on **Formal Terms**, select 'spacing' and click on **Details**. Then click on **Show use in statements**. 18 statements appear.
ix. Not all of these statements are about mucuna. To find only those statements with both 'mucuna' and 'spacing' go to **KB** → **Boolean Search** (top left hand side of the page). Type 'spacing and mucuna' in the search box at the bottom, select 'object' and 'subobjects'. Click on **Search**.

This time there are 14 statements.

- Different plant spacing is given depending on the purpose for which mucuna is grown. Mucuna as a green manure requires closer spacing whereas when it is grown for seed it requires wider spacing. Suggestions for sole cropping and intercropping the cover crop are, however, fairly similar.

x. Return to the Boolean search. Click on the downward arrow under 'Display Kb terms of type', scroll down and select 'topic'. From the list below find 'International research' and add it to the search string so that it says 'spacing and mucuna and 'International research''. Compare the resulting statements with a search for 'spacing and mucuna and 'Ghana research and extension''.

- In general the Ghanaian results suggest closer spacing than the more general international ones.

2. Weeding

xi. Return to the statements for the topic 'Sole cropping of mucuna'.

- Weeding the mucuna cover crop is known to increase establishment (statement 475). However there are contradictions about the number of times this should be carried out (statements 56, 197, 198, 199).
- Sole cropping of mucuna is recommended if the cover crop is being used for the first time to combat aggressive weeds (statement 457).

xii. More comprehensive information about weeding requirements of mucuna is found under the topic 'Weeding requirements of mucuna'.

3. Biomass production

- Two statements suggest quantities of biomass produced by mucuna (statement 172 and 351), one for a particular species in the northern Guinea savanna zone and one for 4 months growth in the transition zone.

xiii. Again, more comprehensive information about biomass production can be found under the topic 'Biomass production of mucuna'.

4. Influence of mucuna on maize yields

- Maize yields are higher in the transition zone after a mucuna cover crop of 4 months growth in the major season than after a *Canavalia ensiformis* cover crop of the same duration (statement 644).
- Under researcher management a mucuna cover crop can produce a 100% yield increase in a subsequent crop (statement 562).

5. Research using fertiliser with mucuna

- Research shows that mucuna cannot supply all of a subsequent maize crop's nitrogen requirements (statement 492). However it appears to be able to supply 50% of a maize crop's NPK requirements (statement 556 – you can check the recommended rate of fertiliser for maize by going to the statement **Details** for this statement, clicking on **Formal Terms**, selecting 'maize_with_recommended_dose_of_fertiliser' and clicking on **Details**).

COMPARING THE KNOWLEDGE OF RESEARCH AND EXTENSION

Knowledge bases can be used to compare what is known by different people. Within the cover crops kb there is knowledge about cover crops from the research community and from extensionists in Ghana.

xiv. Go to **KB** → **Topic Hierarchies…** Select 'Research and extension' and click on **View Tree** to view the topics in the hierarchy.

xv. **Close** all the open dialogue boxes.

xvi. Go to **KB** → **Topics …** Select the topic 'Ghana extension' and click on **Select**, click on **AND** and then choose the first topic in the list 'Application of fertiliser to mucuna' and click on **Search**. There is only one statement for this topic.

xvii. Repeat this procedure, replacing 'Application of fertiliser to mucuna' with other topics about mucuna.

xviii. Compare the knowledge of 'Ghana extension' with the knowledge of the research community by replacing 'Ghana extension' with 'Ghana research' and 'International research' and searching for different topics.

- For the majority of topics about mucuna, there are more statements from research than there are for extension: e.g. 'Application of fertiliser to mucuna' gives 5 statements for research and 1 statement for extension, 'Biomass production of mucuna' gives 79 statements for research and 8 statements for extension. However a few of the topics have similar numbers of statements for research and extension. These are 'Crop interaction with mucuna', 'Intercropping mucuna', 'Seed production of mucuna', 'Sole cropping of mucuna', 'Weeding requirements of mucuna'.

xix. Do a topic search for knowledge of the research community about the weeding requirements of mucuna using the search string '('International research' or 'Ghana research') and 'Weeding requirements of mucuna''.

Knowledge of the research community:

- Establishment of mucuna on land dominated by *Imperata cylindrica* requires the grass to be slashed twice.
- Maize requires weeding 3 times if no cover crop has been grown, but once if it was preceded by a cover crop.
- Mucuna only requires 1 weeding during establishment if it is well done.
- Weeding sole cropped mucuna increases establishment.
- Mucuna does not need weeding during establishment if the spacing is adequate and growth is normal.
- Neglecting to weed volunteer mucuna causes 65% maize lodging and a reduction in maize yield of 35%.
- If mucuna and maize are planted at the same time the mucuna must be weeded 1 to 3 times to prevent it climbing the maize.
- Mucuna is easier to weed than *Imperata cylindrica* and *Chromolaena odorata*.

xx. Repeat the search, but this time using ''Ghana extension' and 'Weeding requirements of mucuna''.

Knowledge of extension:

- Mucuna should be weeded between 2 weeks and 4 weeks after planting if it is sole cropped.
- Mucuna should be weeded twice if it is sole cropped, at 1 week, and 4 weeks after planting.
- Maize requires weeding 2 or 3 times if no cover crop has been grown, but once or twice if it was preceded by a cover crop.
- The control of volunteer mucuna is easy as it does not resprout when cut.
- Weeding increases the establishment and ground cover of mucuna.
- Cover cropping with mucuna increases the ease of weeding of the crop grown after it.

There is some disagreement over the number of times that maize must be weeded after growing a cover crop in comparison to the number of times without a cover crop which suggests that although the benefits in terms of mucuna's suppression of weeds are likely to be positive, they may be variable and the situations in which mucuna provides the most benefits in terms of weed suppression have not been clearly defined by research or passed on to extension.

xxi. Go to **KB** → **Object Hierarchies …**. Select 'mucuna', and then click on **View Tree**. A long list of different types of mucuna can be seen. Some of the names are specific to Ghana and others are used in international research. There has been no uniform way of referring to different types of mucuna and two different names for the same genotype may be used hindering communication and learning about their properties and suitability for use with different cropping patterns.

xxii. Click on **Close** and return to the mucuna hierarchy. Select 'black_seeded_mucuna' and then click on **Object Details**, read the information, click on **Show use in hierarchies**, and **Show use in statements** to view further knowledge. Repeat this procedure for some of the other mucunas listed in the hierarchy.

Continue to explore the knowledge base using the topics and Boolean searches.

LIVELIHOOD AND LAND USE DIAGRAMS

Livelihood and land use diagrams synthesise information about income generating activities and the use of land and other resources by different groups of people within a community. They are intended to be used as part of a Participatory Rural Appraisal exercise.

Participatory Rural Appraisal is a valuable tool that is used both to obtain information and to empower individuals and communities through involving local people in the process of problem definition, data collection, decision making and implementation. However the focus of this tool is less on empowerment, and more on collecting and organising data, and ensuring that the data collected represents the different social groups in the community.

PRA exercises are frequently time consuming and often resource intensive where locations are remote. They result in large amounts of information, which require an equal effort to analyse. Researchers can embark on PRAs without a sufficiently well defined problem or set of questions and many PRAs do not address issues of social relations, the exclusion of particular social groups and gender (Slocum *et al.*, 1998)[1].

It is therefore the intention to provide a tool which:

- Helps researchers maximise the use of existing information, whether it is contained in reports and other documents or is the personal knowledge of local researchers and therefore makes information gathering more cost effective
- Helps to bring greater definition to problems and questions for PRA exercises to answer. It helps researchers to organise existing information. This leads to the identification of gaps in existing knowledge that need to be filled through further targeted research
- Focuses on the analysis of information according to gender and other social classes so that different social groups are not excluded.

The focus of the diagrams is land use by both individuals and households. The following factors are relevant to the natural resource based livelihood strategies of individuals:

- land use
- access to land
- labour
- other income generating activities.

However the information represented can be tailored to the purpose for which the diagram is being drawn. For example research with an agricultural remit will concentrate more on cropping patterns whereas research on the use of forest resources would concentrate more on forest land use. Current definitions of livelihoods are acknowledged (Carney, 1998[2]) and the diagrams are flexible enough to include other capabilities, assets and activities relevant to the livelihoods of individuals or households. The diagrams represent best, land use and income generating activities of individuals and other ways of representing e.g. relationships between different social groups with the community or capturing the dynamic nature of livelihoods, can be used alongside them.

The instructions for drawing the diagrams now follow. As you go through the instructions you should make a list of the information that you do not have or that you are unsure of. In this way you will be able to target any further research to fill in missing the data.

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[1] Slocum R., Wichhart Lori., Rocheleau D., and Thomas-Slayter B. (1998) Power, process and participation – tools for change. Intermediate Technology Publications. London, UK.

[2] Carney D., (1998) Implementing the sustainable rural livelihoods approach in D. Carney (ed.) Sustainable Rural Livelihoods: What contribution can we make? Pp 3 – 26. Department of International Development, London, UK.

DRAWING LIVELIHOOD AND LAND USE DIAGRAMS

The method for drawing livelihood and land use diagrams is divided into two parts. In the first part it is necessary to identify the land use patterns, access to land, use of labour and income generating activities of different members of the population. In the second part the actual drawing of the diagram takes place. An example is given using the village of Oda-Kotoamso, Wassa Amenfi district, Ghana, with the example response following each question.

A IDENTIFYING SOURCES OF INCOME AND LAND USE

1. Identify the target community that you are attempting to describe.

   For this example the target community will be the inhabitants of Oda-Kotoamso, Wassa Amenfi district, Ghana.

2. Make a list of all the different criteria to disaggregate the population within the target area. Our work suggests that gender, age, access to land, ethnic group and marital status (which influences a woman's degree of independence) are all relevant to livelihood strategies. Research with a poverty focus would also include wealth.

   - Gender
   - Age
   - Access to land
   - Ethnicity
   - Marital status

3. List the income generating activities and other sources of income relevant to the people within the target community.

   - Farming
   - Teaching
   - Barbering, carpentry, etc.
   - Agricultural labour
   - *Galamsie* (surface gold mining)
   - Trading
   - *Kenkey* (a maize food) making and other agro-processing activities and trading activities

4. For each activity listed in 2, identify the individuals who take part in the activity. Where the activity is carried out jointly with other individuals consider who a) takes decisions b) holds responsibility c) provides labour for it. Activities can be ranked according to how important they are to different groups within the community.

Source of income	Men	Women	Younger people	Older people	Married people	Single people	Ethnic group *	Access to land #
Farming[1]	●●●●●	●●●●●	●●●●●	●●●●●	●●●●●	●●●●●		
Teaching	●	●	●	●	●	●		
Barbering, carpentry, etc.	●●		●●	●●	●●	●●		
Agricultural daily wage labour (by day)	●●●	●	●●●		●●	●●●		
Galamsie (surface gold mining)	●●●	●	●●●		●●●	●●●		
Kenkey making and other agro-processing activities and trading activities		●●●	●●●	●●●	●●●	●●●		
Income from tree crops elsewhere	●●			●●	●●	●●		
Income from land sale or sharecropping	●●			●●	●●	●●		Land owners

[1] Men and women farm as individuals, rather than as households. Amongst married people men dominate decision making. Responsibility and labour are shared. However wives provide more labour on their husbands' farms than vice versa. Not all married women have their own farms.

* In this example the population consists predominantly of the indigenous Wassa population (>90%). Other ethnic groups present are Brong, Dagarthis, Fanti and Ewe. Due to their low numbers they are not considered in this analysis.

\# Access to land has less influence on the type of income generating activity carried out, but influences more the type of crops grown and cropping pattern.

●●●●● Practiced by almost all (>90%) people

●●●● Practiced by many (>70% and <90%) people

●●● Practiced by quite a few (>50% and <70%) people

●● Practised by some (>20% and <50%) people

● Practised by very few (<20%) people

5. Classify land use within the area. E.g. settlement, cemetery, sacred grove, farmland, fallow land.

- Settlement
- Farm land
- Fallow land
- Cemetery
- Sacred grove
- Agroforestry project land
- CMB cocoa farm land

6. What different types of farm and fallow land can be found within the community? Establish a more detailed classification of farm and fallow land considering parcels of land which are spatially distinct for which land use (within one year or one season) is distinct (in terms of management input, and productive output).

Agricultural land use at Oda

Land use	*Description*
Mature cocoa	Age 8 years or more and fully yielding
Other mature tree crops	Oil palm Citrus Rubber Coffee
Young cocoa	Age 4 – 7 years and not yet yielding to full potential
Other young tree crops	Oil palm Citrus
Mixed food crop farm with the establishment of tree crops	Cocoa is established with plantain, cocoyam and cassava as shade crops with additional vegetable intercrops. Food crops are harvested for three years. The same system is practised for oil palm and citrus although the shade properties of intercrops are less important. Alternatively oil palm may be re-established on old sites as old trees are felled and tapped for palm wine and *akpeteshie*.
Agroforestry (The Oda-Kotoamso Community Agroforestry Project)	Timber trees with Mixed food crops or Maize/cowpea or Cassava or Maize/cassava with Kola or Oil palm or Without any other crop
Food crop farms	1. *Mixed food crops* (subsistence plus surplus) Plantain and cassava are the major crops with some additional intercrops which may include vegetables, cocoyam, yam, maize, cowpea or groundnut. Pepper is the most common vegetable, garden egg, tomato and okro are also grown. Mixtures of crops predominate although parts of the farm may contain a single crop such as yam or cassava. 2. *Intercropping and crop rotation* (cash or subsistence plus surplus) Maize/ cassava intercrop Major season maize and minor season cowpea 3. *Sole cropping* (cash or subsistence plus surplus) Cassava Maize Rice Sugar cane 4. *Vegetables (cash*) Mixtures or sole stands of pepper, garden egg, tomato and okro.

7. Are there any temporal relationships between the land use types previously specified? How is land rotated between different uses?

Fallow land	→	Mixed food crop farm with the establishment of tree crops	→	Young tree crops	→	Mature tree crops	→ Fallow land
Old fallow (secondary forest)	→	Mixed food crop farm with the establishment of cocoa	→	Young cocoa	→	Mature cocoa	→ Fallow land
Agroforestry (The Oda-Kotoamso Community Agroforestry Project) fallow land	→	Mixed food crops or Maize/cowpea or Cassava or Maize/cassava With timber, oil palm or kola	→	Timber, oil palm or kola	→	Fallow land	
Fallow land	→	Food crop farms	→	Fallow land			

8. What type of farms and fallow land specified in 6. do the people specified previously, have? Are some types of farm more important to some people than others (in terms of area of land cultivated, and income derived from that land)? This information can be ranked. How does each individual gain access to each type of land?

Land use	*Men*	*Women*	*Younger people*	*Older people*	*Married people*	*Single people*	*Ethnic group*	*Access to land*
Mature tree crops – cocoa	●●●●● VFGP	●●● FG	● FG	●●●●● VFG	●●●●● VFG	●●●●● VFG		SPA - settlers
Young tree crops – cocoa	●●●●● FGP	●●● FG	●●●●● FG	●●●● FG	●●●●● FG	●●●●● FG		
Mixed food crop farm with the establishment of tree crops – cocoa	●●●●● FGP	●●● FG	●●●●● FGP	●● FG	●●●●● FG	●●●●● FG		
Mature tree crops – other	●●● FG			●●● FG	●●● FG	●●● FG		
Young tree crops – other	●●● FG			●●● FG	●●● FG	●●● FG		
Mixed food crop farm with the establishment of tree crops – other	●●● FG			●●● FG	●●● FG	●●● FG		
Mixed food crops or Maize/cowpea or Cassava or Maize/cassava With timber, oil palm or kola	●●● AF	● AF	●●● AF	● AF	●●● AF	●●● AF		
Mixed food crops (subsistence plus surplus)	●●● FG	● FG	●●● FG	●●● FG	●●● FG	●●● FG		
Intercropping and crop rotation (cash or subsistence plus surplus)	●●● FG	● FG	●●● FG	● FG	●●● FG	●●● FG		
Sole cropping (cash or subsistence plus surplus)	●●● FG		●●● FG	● FG	●●● FG	●●● FG		
Vegetables (cash)	●●● FG		●●● FG	● FG	●●● FG	●●● FG		

Key	*Means of acquisition of land*
●●●●●	Practiced by almost all (>90%) people
●●●●	Practiced by many (>70% and <90%) people
●●●	Practiced by quite a few (>50% and <70%) people
●●	Practised by some (>20% and <50%) people
●	Practised by very few (<20%) people
V	Clearing of virgin or otherwise unclaimed forest
F	Family land and inheritance
G	Gift
S	Sharecropping
P	Purchase
A	The Oda Kotoamso Community Agroforestry Project

9. What livestock are kept, in what numbers and by whom? Are they integrated with crops, and if so, how?

Livestock	*Men*	*Women*
Sheep <10	+	-
Goats are taboo	-	-
Poultry <100	+	+

All categories of people own livestock - single people, married people, younger and older people. However women tend to keep only poultry whereas men may own sheep also. Livestock are not integrated with crops at Oda but roam around the settlement. Manure is not used to fertiliser crops.

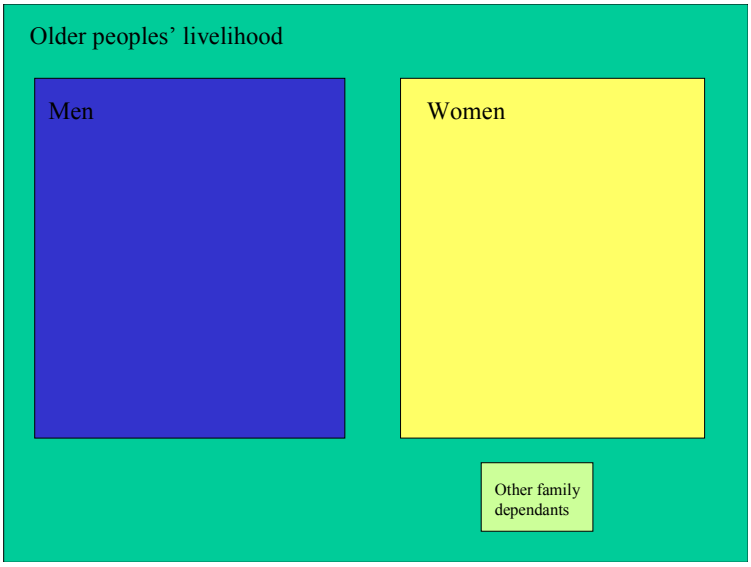
10. From the disaggregated information above decide which different groups of individuals in the community have sufficiently different livelihoods to be considered separately.

- Older men
- Younger men
- Older married women
- Older single (divorced or widowed) women
- Younger women

B DRAWING THE LIVELIHOODS AND LAND USE DIAGRAM

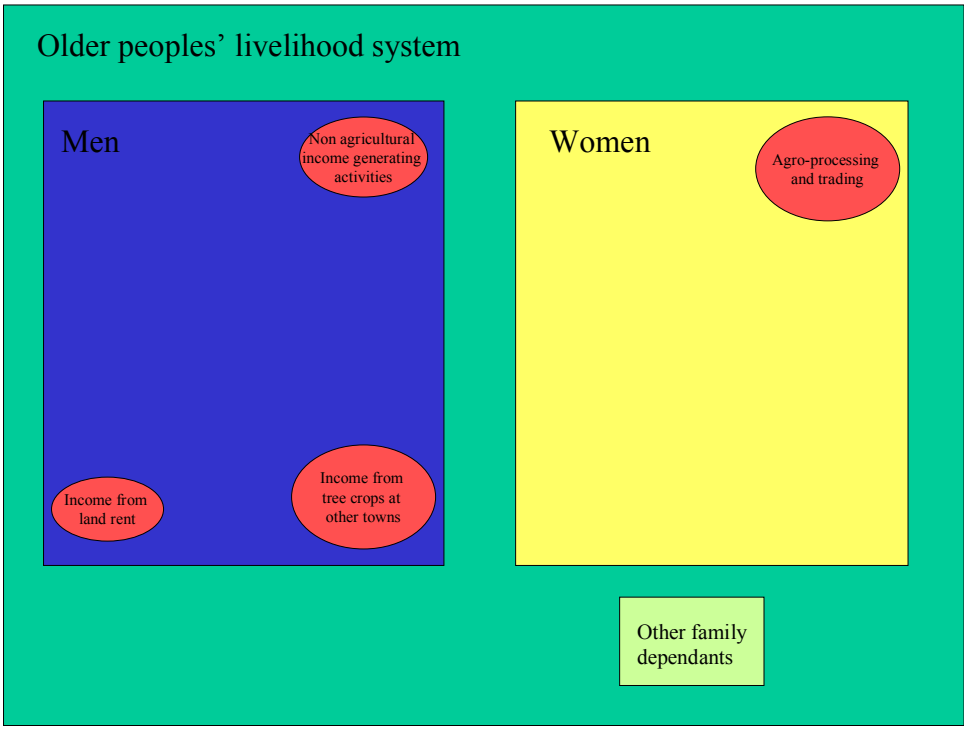
11. Decide upon suitable boundaries for a household. Represent the household with a box.

12. Which members of the household should be represented on the diagram? Group the individuals specified in 10. to represent characteristic households. Represent these individuals within the box. Identify the other individuals in the household e.g. child dependants and add them to the diagram.

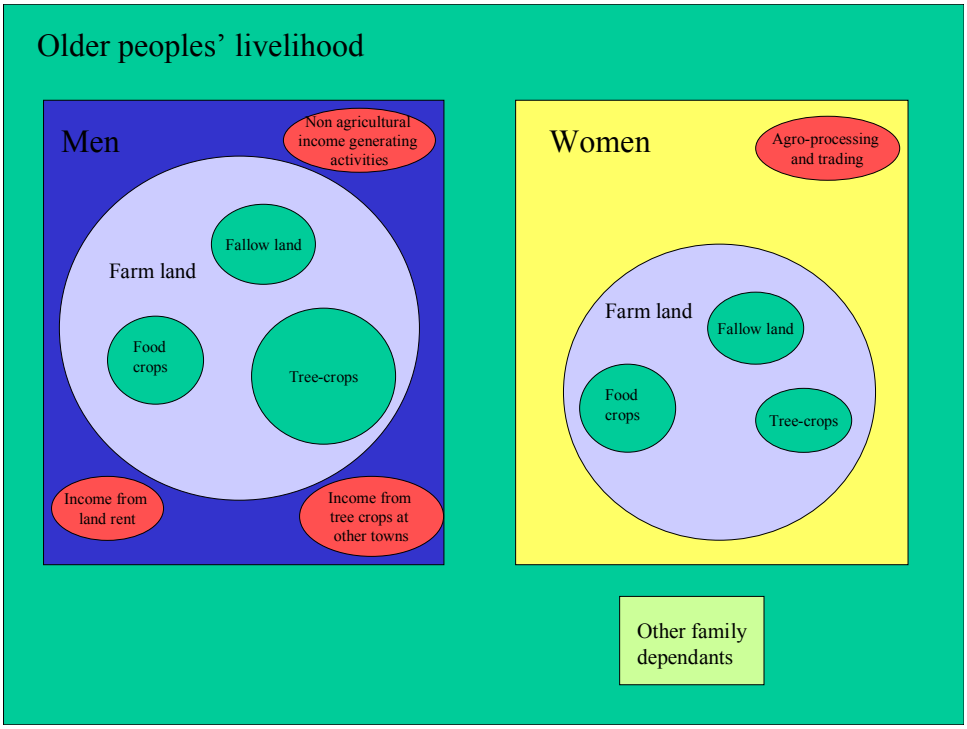


For this example we are taking older men and older women (wives). Other dependants are loosely defined and include resident children and nephews.

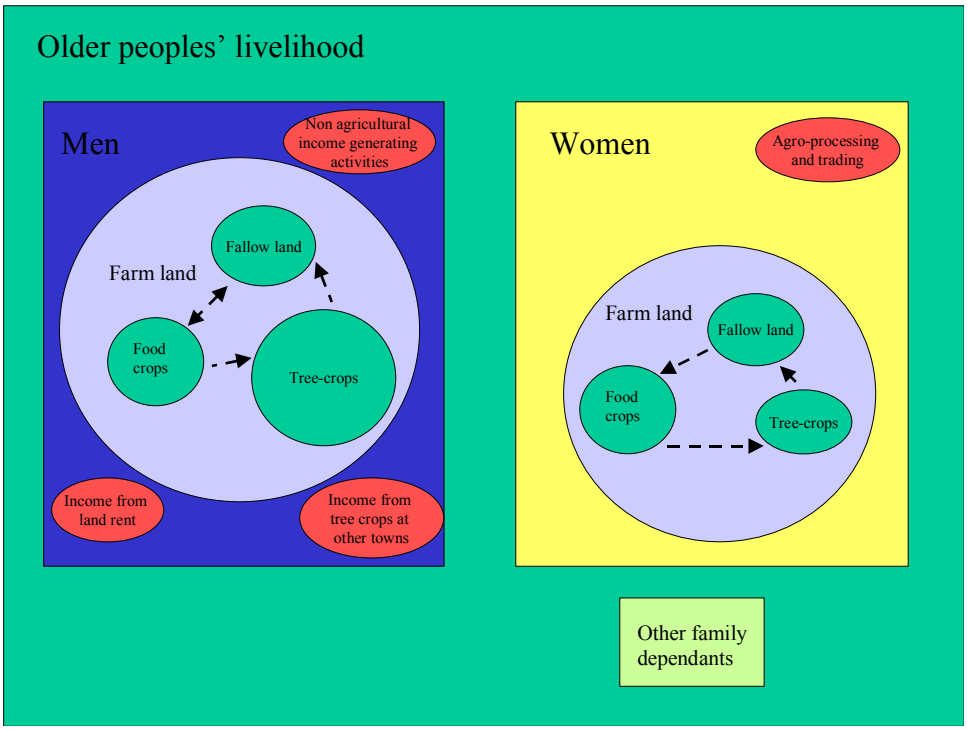
13. Represent the income generating activities identified for these individuals in 4. in the boxes



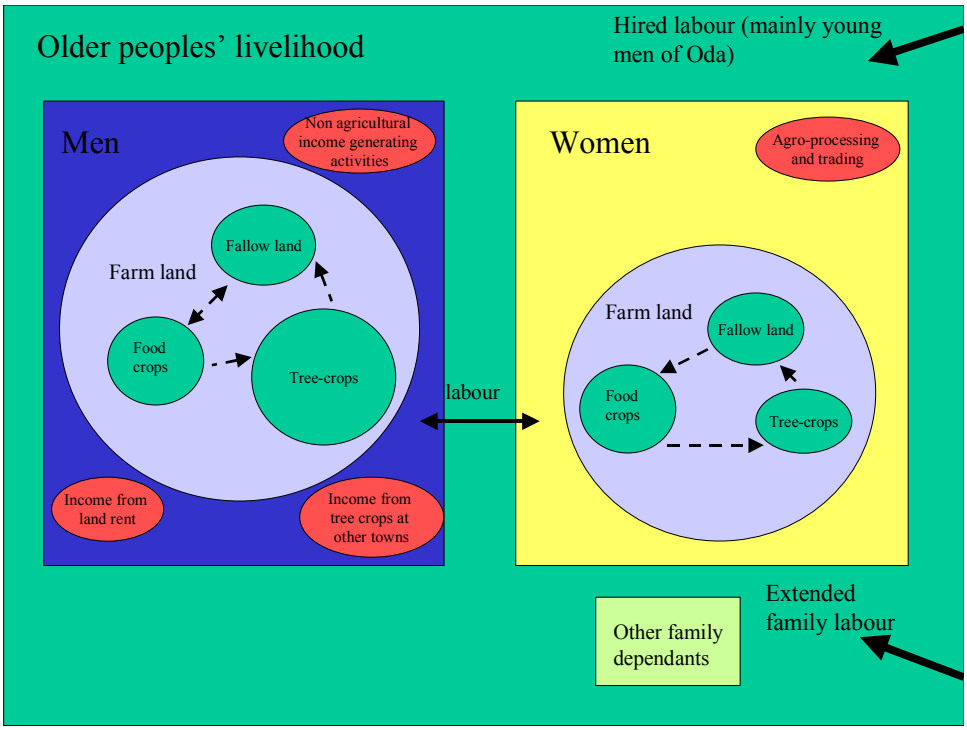
14. Represent land use identified in 8. for each individual. For the example below the emphasis will be on agricultural land use.



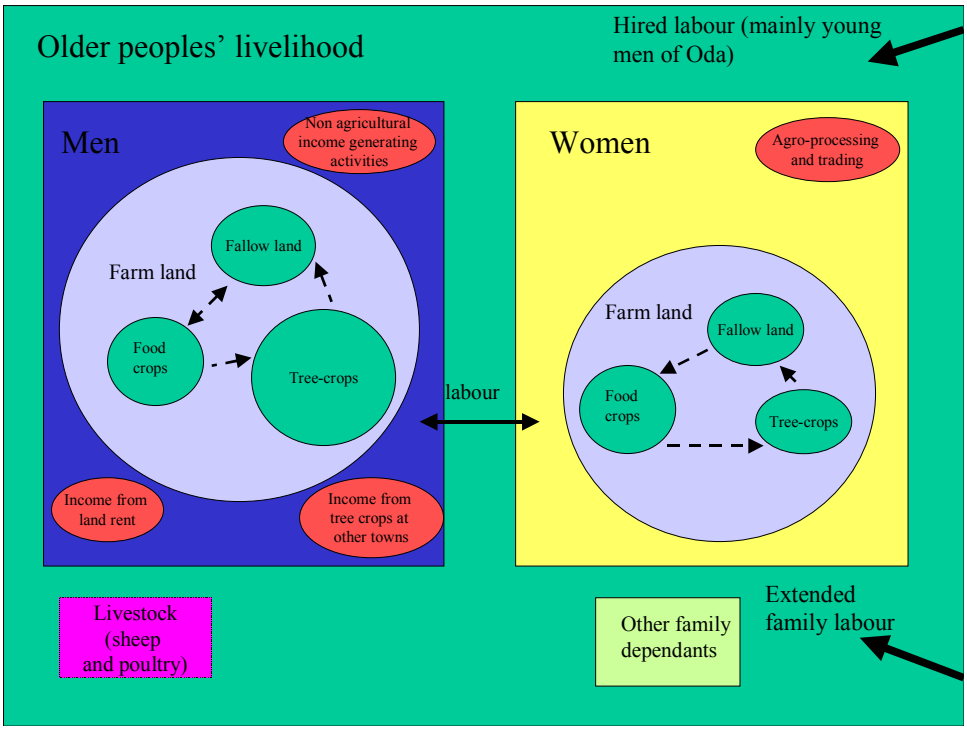
15. Add temporal relationships to land use using dotted arrows.



16. Indicate the sources of labour used for agricultural activities using full arrows. Include labour sharing strategies within the household and labour that is brought in from outside the household.

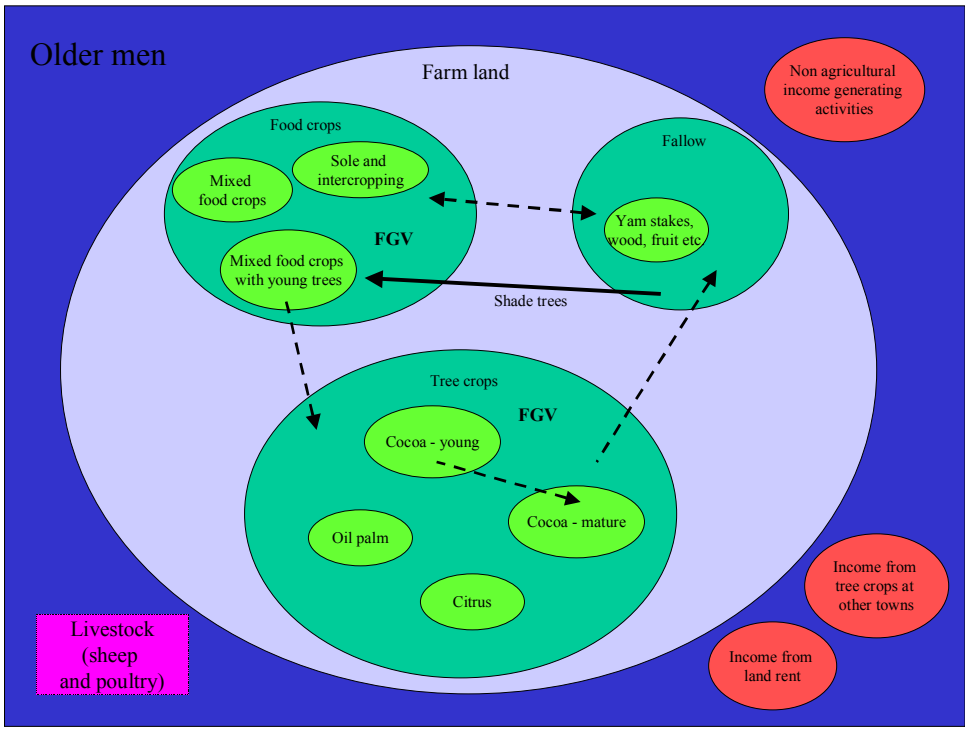


17. Represent livestock on the diagram indicating any relationships which integrate livestock with crops.

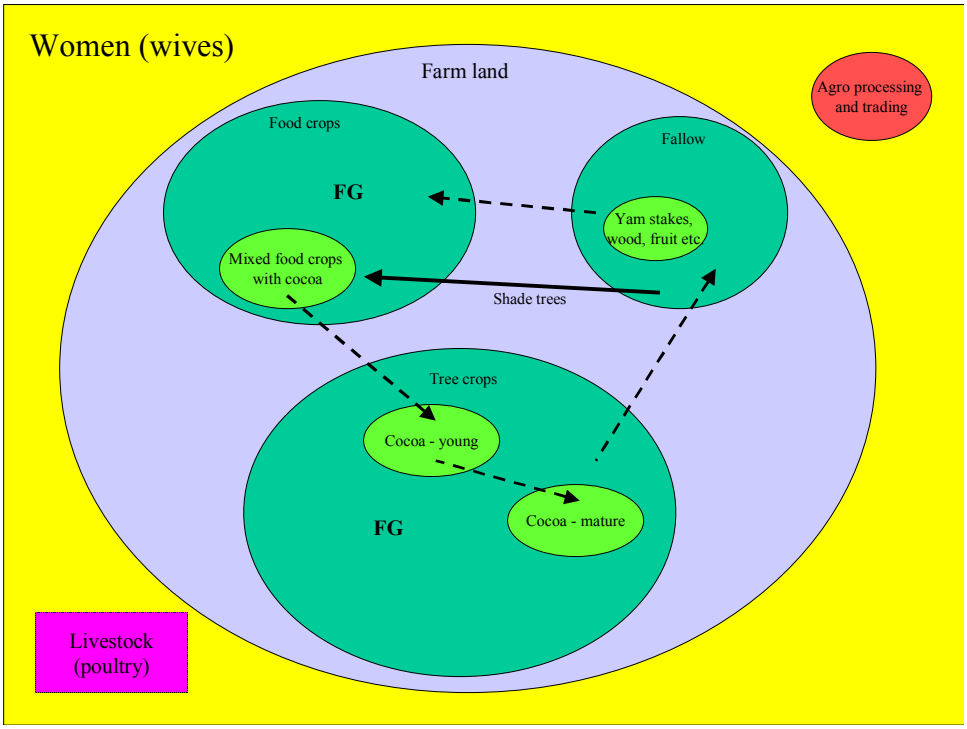


18. Separate diagrams can be drawn to represent the land use patterns of different individuals in more detail. These may include details of land access and cropping patterns.

Livelihoods and land use of older men



Livelihoods and land use of older women



TECHNOLOGY CHOICE TOOL

This tool brings together information about livelihoods and technologies to facilitate the choice of appropriate technologies based on farmers' circumstances. It can be used in two ways:

1. ***Technology to target group***: given a particular technology , the tool can be used to suggest a target group of farmers for whom it is suitable
2. ***Target group to technologies***: given a particular target group, it can be used to produce a set of criteria which an appropriate technology must fulfil.

Where the necessary statistics are available the tool can be used to help prioritise research work by providing information on the size of a potential target group for a particular technology.

The tool can also be used to produce a list of additional requirements that must be met if a technology is to be adopted by a particular target group. E.g. using a mucuna cover crop to raise maize yields by 50% in the Brong Ahafo region may only provide sufficiently substantial cash benefits to be adopted if farmers are able to store the maize and wait until the price rises before selling it. This is likely to require sufficient control over cash flow to prevent the necessity of selling early and additionally, adequate storage technology to minimise post harvest losses.

METHOD 1: TECHNOLOGY TO TARGET GROUP

1. Identify the technology

2. Identify the target area e.g. the forest and transition zones of Ghana

3. List all the different criteria to disaggregate the people within the target area. Our work suggests that location, gender, age, ethnic group, origin (which frequently influences the terms of access to land) and marital status (which influences the degree of independency or dependency of a person and the roles they must fulfil) are all relevant to livelihood strategies and opportunities for the uptake of new technologies. Wealth is also likely to be an important factor.

4. Consider the following questions in relation to the technology you have chosen and fill in the table that follows them.

Factors that influence farmers' ability to adopt a technology

Crops and cropping patterns (1)

- Which crops and cropping patterns that are practiced within the community is your chosen technology suitable for, which is it unsuitable for?
- What modifications would be necessary to current cropping patterns to enable farmers to adopt the technology?

Inputs

- What inputs (organic or inorganic) are required for the technology you have chosen?
- Can they be obtained, whether freely or for sale?
- Are there any other requirements which must be met to obtain the input e.g. in terms of organisation, personal contacts, travel, transportation of the input to the farm. How many visits are required by the farmer before the input is obtained?

Labour availability

- What additional labour is required for the technology?
- When is it necessary?
- Is labour available at this time?

Capital availability

- How much capital is required to finance the use of this technology in terms of:
  - Cost of inputs
  - Costs associated with obtaining inputs e.g. cost of transport to purchase inputs, cost of transportation of inputs to the farm
  - Cost of additional labour required to use the technology

Cash flow

- When is cash necessary for the technology?
- Is cash available at this time? (Cash flow may be represented on a seasonal calendar, together with labour requirements and marketing of the crop).

Land type and soil fertility

- What type of land or soil is necessary for the technology to produce effective results? (E.g. some technologies will only produce significant yield increases on poor soil).

Marketing of produce

- Will farmers be marketing a new crop? If so, is a ready market available? If it is not, will farmers be willing and able to market the crop themselves? (I.e. will they be able to transport the crop to market, and what will the transaction costs be?)
- Does practising the technology change the harvesting date? If so, what influence does this have on farmers' ability to market the crop, and the returns that they receive from it? (I.e. are buyers available at this time? Is the market price for the crop more, less, or the same as if the crop were harvested at the original time?)

Tenure conditions

- What tenure conditions are necessary to practice the technology?

Farmers' knowledge

- What are the minimum knowledge or training requirements for the technology to be effective?
- What do farmers already know about the technology or the principles behind it?
- Do they have any additional knowledge that will influence their willingness or ability to practise it?

Other beliefs

- Do farmers hold any beliefs that would influence their readiness to accept your chosen technology e.g. the belief that animal manure is dirty?

Farm management

- What are the management requirements of the technology, over and above any changes in labour requirements? I.e. is constant vigilance and frequent trips to view the farm required? Is precise timing of management actions required or is the timing of management actions flexible? Are farmers able to provide sufficient management for the technology to be effective?

Factors that influence the effectiveness of a technology

Marketing issues

- Will farmers benefit from storing the crop and selling it at a later date in conjunction with using the soil fertility management technology? If so, do farmers have adequate knowledge of post harvest storage technology to minimize losses? Do they have the materials (storage facilities and other inputs such as chemicals) to store the crop? Are they able to manage their cash flow situation sufficiently in order not to need cash at an earlier date and so to sell early?

Capital returns

- Does the technology increase or reduce capital costs?

Changes in labour

- Overall i.e. considering several cropping seasons and at a household level, do labour requirements change as a result of using the technology? If so, is there an overall increase or a decrease in the amount of labour required?
- At an individual level, who is likely to pay for, or to perform additional labour associated with the technology?
- Who is likely to benefit from reduced labour requirements associated with the technology?

Crops and cropping patterns (2)

- Having considered all of the above factors, reconsider again which crops and cropping patterns the technology is suitable for.

Factors	*Requirement*	*Ability of different groups of farmers to satisfy requirements*						
		a	*b*	*c*	*d*	*e*	*f*	*g*
Requirements influencing farmers' ability to adopt the technology								
Target crops (1)								
Cropping patterns (1)								
Inputs								
Labour availability								
Capital availability								
Cash flow								
Land type and soil fertility								
Marketing of produce								
Tenure conditions								
Farmers' knowledge								
Other beliefs								
Farm management								
Factors that influence the effectiveness of a technology								
Marketing issues								
Capital returns								
Changes in labour								
Target crops (2)								
Cropping patterns (2)								

5. How do the factors outlined in 4 affect the ability of the different groups of farmers identified in 3 to adopt the specified technology? Put the names of the different groups of farmers into the table (top, right). Then, using the appropriate columns, indicate which groups are able to satisfy the requirements of the technology.

Example 1: Use of poultry manure as a substitute for inorganic fertiliser in commercial vegetable production

Technology: poultry manure for commercial vegetable production
Target group: farmers at Subriso No. 3 in Tano district, Brong Ahafo region

Factors	*Requirement*	*Ability of different groups of farmers to satisfy requirements*			
		Older settler men	*Older settler women*	*Younger settler men*	*Younger settler women*
Requirements influencing farmers' ability to adopt the technology					
Target crops (1)	Commercial vegetable production	+	-	-	-
Cropping patterns (1)	Any[1]				
Inputs	Poultry manure[2]	-	-	-	-
Labour availability	Labour for transportation of manure and incorporation	+	-	+	-
Capital availability	Cash for transportation of manure and additional labour costs	+	-	+	-
Cash flow	Cash required prior to planting of vegetables (2 main seasons at Subriso)	+	+	+	+
Land type and soil fertility	Any[3]				
Marketing of produce	No additional requirements[4]				
Tenure conditions	Any				
Farmers' knowledge	Some[5]	-	-	-	-
Other beliefs	Some[6]	-	-	-	-
Farm management	Some[7]	+	+	+	+
Factors that influence the effectiveness of a technology					
Marketing issues	None				
Capital returns	Reduction in costs[8]	+	+	+	+
Changes in labour	Small increase				
Target crops (2)	Vegetables	+	-	-	-
Cropping patterns (2)	Any				

[1] A second crop may benefit from residual effects but the influence on the vegetable crop is more likely to persuade farmers to adopt the technology.
[2] There is one intensive poultry farm in the district but it is at a distance of over 40km from Subriso.
[3] As fertiliser is used with benefits on all soils the situation with poultry manure is likely to be similar.
[4] Increases in yield are not expected by replacing inorganic fertiliser with poultry manure.
[5] Time for manure to decompose, rate and method of application.
[6] Manure is considered to be dirty and using it is considered an old-fashioned practice.
[7] Some organisation is necessary to transport the manure prior to the time of cropping. Commercial vegetable farming, particularly tomato already has high management requirements and so this not likely to be a problem for current producers.
[8] Capital requirements for transportation of manure are less than for fertiliser.

This technology has a relatively simple specification, and is already targeted fairly narrowly to commercial vegetable producers. Therefore the target group and the factors that will influence uptake are fairly clear. Commercial vegetable producers are predominantly men – with more young men than older men engaged in production.

The main constraint to adoption of the technology is that poultry manure is not available near Subriso. If poultry manure, or a suitable alternative were available then additional considerations would have to be made.

Some additional organisation and labour would be required on the part of farmers to obtain manure, allow time for decomposition prior to use and for application. Farmers are more likely to undertake these if use of the manure is effective in reducing capital costs for the purchase of fertiliser. This is likely to depend on the costs involved in obtaining the manure. Some knowledge of how to use poultry manure is also required although the technology is relatively simple. Awareness raising would be required to demonstrate its relevance and to help overcome traditional prejudices against the use of animal manure.

Example 2: Clearing without burning

Technology: clearing fallow land without burning.
There are two options for this technology. For the first option (1) land is cleared manually and crops are planted through the trash. For the second option (2) herbicide is used and crops are again planted through the trash.
Target group: farmers within the peri-urban area of Kumasi

Factors	*Requirement*	*Ability of different groups of farmers to satisfy requirements*			
		Older men	*Older women*	*Younger men*	*Younger women*
Requirements influencing farmers' ability to adopt the technology					
Target crops (1)	1: any 2: any				
Cropping patterns (1)	1: any 2: any[9]				
Inputs	1: none 2: herbicide[10]	+ +	+ +	+ +	+ +
Labour availability	1: none 2: labour for spraying of herbicide during land preparation	+ +	+ -	+ +	+ -
Capital availability	1: none 2: capital for herbicide and spraying equipment	+ +	+ -	+ +	+ -
Cash flow	1: none 2: cash required during land preparation	+ +	+ +	+ +	+ +
Land type and soil fertility	1: secondary forest fallows without persistent weeds 2: fallows dominated by grasses or *Chromolaena odorata*[11]	- +	- +	- +	- +
Marketing of produce	1: none 2: none				
Tenure conditions	1: none 2: none				
Farmers' knowledge	1: some 2: some[12]	- +	- -	- +	- -
Other beliefs	1: none 2: none				
Farm management	1: none 2: timing of clearing and application of herbicide	+ +	+ +	+ +	+ +

[9] Mulching may provide more effective results in the dry season due to conservation of soil moisture.
[10] Herbicide can be purchased in the central market in Kumasi.
[11] If land is not burnt and no herbicide is applied land with persistent weeds such as *Panicum maximum* and *Chromolaena odorata* will become very weedy during cropping thus increasing weeding requirements. Herbicide use is suitable for shorter fallows with more persistent weeds such as *Panicum maximum* or *Chromolaena odorata* so that (a) the quantity of vegetation does not impede farm work and (b) the cost of herbicide is likely to be less than the cost of repeated manual weeding.
[12] Farmers know mulching and the decomposition of plant matter increases the fertility of the soil and that burning has both positive and negative effects on the farm including aiding the sprouting of cocoyam. They consider mulching instead of burning to be suitable for plantain, which is not damaged by movement around the a farm littered with tree branches and other debris, unlike crops such as maize. Farmers believe herbicide also acts like fertiliser. They need to know the rate and method and timing of application of herbicide. This is taught by extension agents and therefore, in the first instance, is more likely to be known by men than women.

Factors that influence the effectiveness of a technology					
Marketing issues	1: none 2: none				
Capital returns	1: variable 2: potential increase[13]	- +	- -	- +	- -
Changes in labour	1: variable 2: potential decrease[14]	- +	- -	- +	- -
Target crops (2)	1: plantain 2: commercial vegetable, maize and rice production	- +	- -	- +	- -
Cropping patterns (2)	1: sole cropping 2: any				

This technology has two variations and two target groups:

1. ***Without herbicide***: weeds are likely to be a significant problem if herbicide is not used, particularly on shorter fallows. On longer fallows, which have lesser weeding requirements and in conjunction with the mulching of vegetation debris, plantain and other perennial crops can be grown that are not damaged by the tree branches and other debris left on the farm. However long fallows are very rarely found in the peri-urban Kumasi area and plantain does not thrive on shorter fallows in this area. Therefore this is not an option for farmers.
2. ***With herbicide***: after short fallows where smaller amounts of biomass have been produced any crops can be grown and access to the farm is not impeded. However cash crops can better justify purchase of the herbicide. Where use of herbicide is effective in weed control, weeding or expenditure on weeding may be reduced. These circumstances are most applicable to vegetable, rice and green maize farmers where there is intense pressure on lowlands and valley bottoms. Cash returns with use on lower value cash crops such as upland maize would need to be calculated to suggest further suitability.

[13] 1: Where fallows are long and weeds are few yields may remain the same or increase, but if further expenditure is incurred on weeding requirements returns are likely to decrease.
2: Effective herbicide use may reduce cash required for weeding. With low sales of farm produce herbicide is likely to reduce cash returns. It is therefore more likely to be used for commercial vegetable, maize and rice production.

[14] See previous footnote.

METHOD 2: TARGET GROUP TO TECHNOLOGY

1. Identify the target group of farmers.
2. Consider how the following issues offer opportunities and constraints to the target group.

Factors that influence farmers' ability to adopt a technology

Crops and cropping patterns

- Which crops are grown by farmers?
- How would farmers benefit by improving soil fertility for these crops? (E.g. in terms of increased cash income, food security, or better cash flow).
- What cropping patterns are followed?

Inputs

- What inputs (organic or inorganic) are available for your chosen farmers?

Labour availability

- What labour sources are available to these farmers (own labour, family, hired, shared etc.)?
- When is labour most available and least available?

Capital availability

- What level of capital do farmers have available to invest in soil fertility management?

Cash flow

- When is cash flow good, and when is it poor?
- When do farmers need to improve cash flow?

Land type and soil fertility

- What type of land or soil is available to farmers? What is not available?

Marketing of produce

- What are farmers' marketing opportunities in terms of different commodities and the time of year? What are the marketing constraints?

Tenure conditions

- What are farmers' terms of access for different types of land or different crops? How long do farmers have secure tenure for? Are there any restrictions on how they can cultivate land? Do they feel that land may be taken away from them if they make some visible improvements to soil fertility?

Farmers' knowledge

- What are farmers' sources of knowledge?
- What do farmers already know about soil fertility management – about particular technologies or principles behind soil fertility management in general?

Other beliefs

- Do farmers hold any beliefs that would influence their readiness to accept a new technology e.g. the belief that animal manure is dirty?

Farm management

- What level of management are farmers able to provide for individual farms? Are they able to visit the farm frequently to monitor crop development? Are they able to carry out management actions such as weeding, at precise times? Are they able to provide adequate supervision of hired labour?

3. Fill in the following table using your responses to the questions above.

A suitable technology specification is one that uses stated opportunities but does not aggravate constraints.

Sometimes constraints which pose problems in terms of farmer uptake of a technology can be resolved by offering additional technologies e.g. the provision of credit facilities may enable farmers to invest in a technology that they would not otherwise be able to. These are potential interventions where a more coordinated approach to technology development or dissemination is necessary.

Factors	*Opportunities*	*Constraints*
Target crops		
Cropping patterns		
Inputs		
Labour availability		
Capital availability		
Cash flow		
Land type and soil fertility		
Marketing of produce		
Tenure conditions		
Farmers' knowledge		
Other beliefs		
Farm management		

Example 3: Soil fertility management technologies for young men at Oda in the Wassa Amenfi district

Target group: young male Wassa farmers at Oda in the Wassa Amenfi district

Factors	*Opportunities*	*Constraints*
Target crops	Cocoa and oil palm – especially young trees Short term cash crops (maize, cowpea, cassava) Plantain, cocoyam, vegetables for home consumption	
Cropping patterns	Mixed cropping during the establishment of cocoa with plantain, cocoyam, cassava, maize and vegetables Maize/cowpea rotation Maize/cassava intercrop Sole cropping of cassava, maize Formal agroforestry – food crops with oil palm or kola nut and timber trees	
Inputs	Inorganic fertiliser Small quantities of sheep and goat manure	Large quantities of manure
Labour availability	Sources: own and wife Most hired labour available: April and June	Sources: not able to purchase labour or mobilise other family labour Least hired labour available: November to December
Capital availability		Limited
Cash flow	High availability: August to December	Low availability: January to July Least available: May to July
Land type and soil fertility	Land with a short fallow and some swampy areas	Not able to obtain large areas of land with a long fallow
Marketing of produce	*Gari* processing from cassava Cowpea	Poor market links for sale of vegetables
Tenure conditions	Secure tenure on inherited land Agroforestry project land: trees must be planted	
Farmers' knowledge	There are many resource persons available in the village	Infrequent visits from extension agent
Other beliefs		Manure is perceived as dirty
Farm management	Very young under-employed farmers have ample time for good farm management.	Farmers who are a little older with a larger number of parcels and who also do agricultural wage labour are busier.